Instruction Manual

2531
Digital Power Meter (Three Phas

USER'S MANUAL

IM 253120-01
1st Edition

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2531
Digital Power Meter (Three Phase)

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Foreword

Thank you for purchasing the YOKOGAWA Model 2531 Digital Power Meter.
This User's Manual contains useful information regarding the instrument's functions and operating procedures as well as precautions that should be observed during use. To ensure proper use of the instrument, please read this manual thoroughly before operating it.
Keep the manual in a safe place for quick reference whenever a question arises.

Notes

- The contents of this manual are subject to change without prior notice.
- Every effort has been made in the preparation of this manual to ensure the accuracy of its contents. However, should you have any questions or find any errors, please contact your dealer or YOKOGAWA sales office.
- Copying or reproduction of all or any part of the contents of this manual without YOKOGAWA's permission is strictly prohibited.

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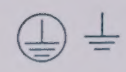
SAFETY PRECAUTIONS

The 2531 Digital Power Meter is a Safety class I instrument (provided with a terminal for protective grounding).
The following general safety precautions must be observed during all phases of operation, service and repair of this instrument. Failure to comply with these precautions or with specific WARNINGS given elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument.
YOKOGAWA Electric Corporation assumes no liability for the customer's failure to comply with these requirements.

General definitions of safety symbols used on the instrument and in manuals

Explanation: to avoid injury, death or damage to the instrument, the operator must refer to the explanation in the manual.



Protective Grounding Terminal: to protect against electric shock in the case of a fault. This symbol indicates that the terminal must be connected to ground before operation of the instrument. When this symbol is not enclosed in a circle, it represents a Function Grounding Terminal. Such terminals should not be used as a "Protective Grounding Terminal".

WARNING

A WARNING sign denotes a hazard. It calls attention to a procedure, practice or condition, which, if not correctly performed, adhered to, or maintained, could result in injury or death.

CAUTION

A CAUTION sign denotes a hazard. It calls attention to a procedure, practice or condition, which, if not correctly performed, adhered to, or maintained, could result in damage to or destruction of part of the product.

WARNING

Power Supply

Ensure that the source voltage matches the voltage of the power supply before turning on the power.

Power Cord and Plug

To prevent an electric shock or fire, be sure to use the power supply cord and the 3-pin to 2-pin adapter supplied by YOKOGAWA. The mains power plug can only be plugged into an outlet with a protective grounding terminal. Use of an extension cord having no protective grounding wire will invalidate the protection feature.

Protective Grounding

Be sure to connect the protective grounding to prevent an electric shock before turning on the power. A 3-pin power cord is supplied with this instrument. Connect the power cord to a 3-pin AC outlet with a protective grounding terminal. If you use a 3-pin to 2-pin adapter, connect the grounding wire of the adapter to the protective grounding terminal of the AC outlet.

Necessity of Protective Grounding

Never cut off the internal or external protective grounding wire or disconnect the wiring from the protective grounding terminal. Doing so creates the possibility of an electric shock.

Faulty Protection Feature

Never operate the instrument if the protective grounding or fuse appears faulty. Before commencing operation, always make sure that the protection feature is free of faults.

Fuse

To prevent fire, be sure to use a fuse with the specified ratings (current, voltage and type). Before replacing the fuse, turn OFF the power and unplug the power cord. Do not use any fuse other than the specified one. Also do not short-circuit the fuse holder.

Do not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or vapors. Operation of any electrical instrument in such an environment constitutes a safety hazard.

Do not Remove any Covers

There are some areas with high voltage. Do not remove the cover if the power supply is connected. The cover should be removed by qualified personnel only.

External Connection

Before connecting the instrument to the object to be measured or the external control circuit, make sure that protective grounding is in place.

How to Use this Manual

Structure of this Manual and its Use

This User's Manual consists of 14 chapters, an Appendix and an Index. If you are using this instrument for the first time, we suggest that you read Chapter 1 before starting operation. If you encounter an unfamiliar term, refer to the index to find the page reference.

Chapter	Main Contents
1	Main features, functions and the name of each part of the power meter
2	Contents of the package, general precautions for use, installation method, how to turn the power on and off, and setting the date and time
3	How to connect the object to be measured, input element selection, and display using function keys
4	Setting measuring conditions and ranges
5	Operation method for measuring voltage, current, active power and peak values, and for display of computed apparent power, reactive power, power factor and phase angle
6	Setting and operation for integration of active power and current
7	Operation method for measurement of frequency
8	Setting and operation of efficiency, MATH, scaling and averaging functions
9	Printing measured values and set-up information using the built-in printer
10	Remote control and D/A output
11	Communications using a GP-IB or RS-232-C interface
12	Storing, recalling and initializing set-up information, key lock operation, and back-up function for set-up information
13	Possible causes of an alarm and corrective actions, description of error codes and corrective actions, replacement of the power supply fuse, and calibration
14	Specifications of the instrument
Appendix	Description of communications commands and sample programs
Index	Description of important terms

Conventions Used in this Manual

Symbols used

The following symbols are used in this User's Manual.

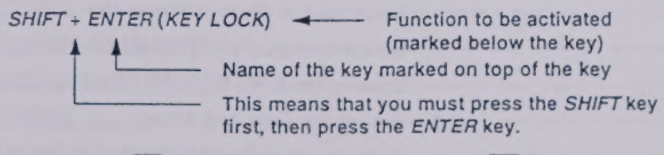
WARNING ..... Describes precautions that should be observed to prevent danger of injury or death to the user.

CAUTION ..... Describes precautions that should be observed to prevent damage to the instrument.

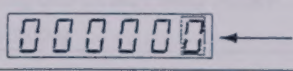
Note ..... Provides information that is important for proper operation of the instrument.

Key Operation Rules

- To activate the function marked below a key, first press the *SHIFT* key (to light up the green indicator), then press the key. The sequence for key operation is described as follows in this manual.


SHIFT + ENTER (KEY LOCK)
Function to be activated (marked below the key)
Name of the key marked on top of the key
This means that you must press the SHIFT key first, then press the ENTER key.

- On the display, "□" means that the digit indicated by "□" is blinking.



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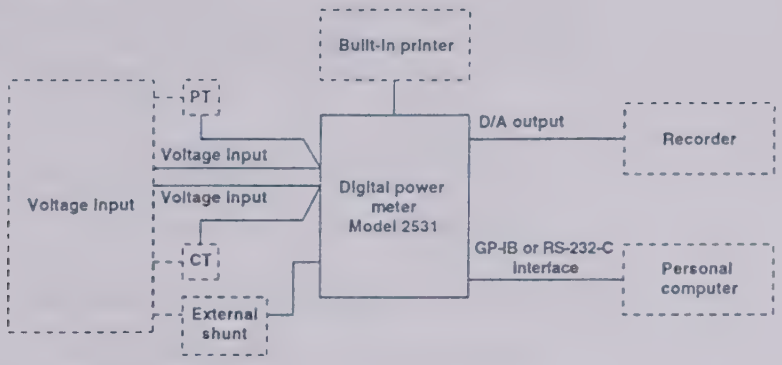
1.1 Features

The 2531 Digital Power Meter is compact and capable of highly accurate measurement of both DC power and AC power ranging from 2 Hz up to 200 kHz. It can handle various input systems, from single-phase to three-phase, four-wire and three-voltage three-current systems.

- High accuracy: 0.05% of reading + 0.05% of range
- Wide frequency range: DC and AC, 2 Hz to 200 kHz
- Capable of direct measurement of currents of up to 30 A (rms) and 60 A (peak)
- The voltage and current circuits are insulated from each other as well as from the main body's case.
- Selectable measuring range and mode for each input element enables use of this meter as if it were 3 combined voltmeter/ammeter units.
- Use of high-speed A/D converters enables simultaneous sampling of voltage and current inputs for all three phases, making real-time measurement possible.
- Use of a MATH function enables calculation of input-to-output efficiency, crest factor and impedance by means of four arithmetic operations on values displayed in displays A and B.
- Use of a harmonic analysis function enables measurement of up to the 49th harmonic of voltage, current and power as well as relative harmonic content in accordance with IEC555-2. (Optional)
- Four 7-segment LED displays enable simultaneous measurement of four data.
- Either a GP-IB or RS-232-C interface is provided as standard according to the customer's preference. Use of a communications function with this interface enables simultaneous acquisition of up to 14 measured/computed data.
- A scaling function is also available. This is very convenient when an external potential transformer (PT) or current transformer (CT) is connected to the instrument.
- Measuring range for external shunt is also provided.
- In the case of an input voltage or current peak overflow, the PEAK OVER LED informs the user which channel the peak overflow is occurring on.
- The built-in printer enables print-out of measured and preset data as well as bar graphs for analysis of harmonics (optional).

1.2 System Configuration and Functional Block Diagram

System Configuration



Functional Block Diagram

Operation Principle and Circuit Structure

The 2351 Digital Power Meter consists of various sections; input (voltage input and current input circuits), DSP, CPU, display and interface sections.

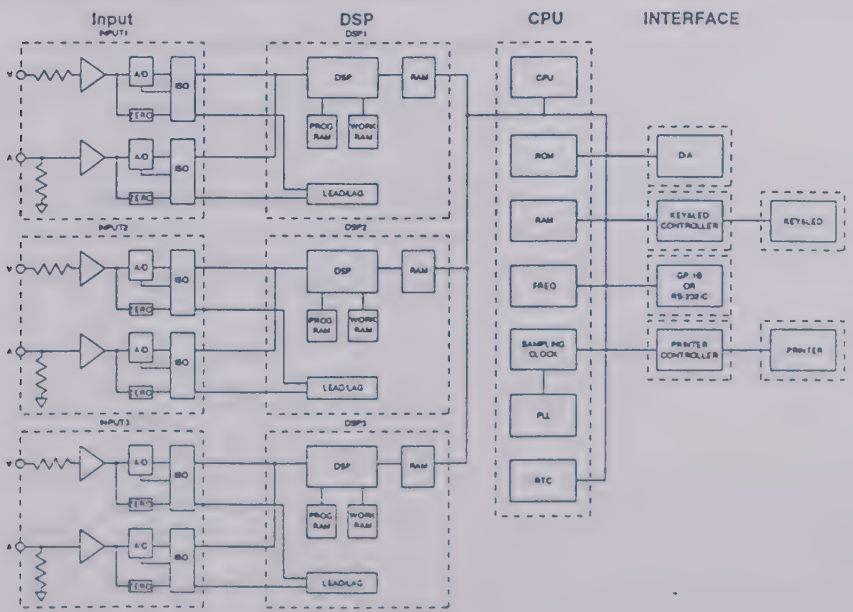
In the voltage input circuit, the input voltage is formalized by a voltage divider and operational amplifier, then sent to the A/D converter.

In the current input circuit, one shunt resistor is used to form a closed circuit. The voltage between both ends of the shunt resistor is amplified and formalized by an operational amplifier and then sent to the A/D converter. This method enables switching of the current range without opening the current measurement circuit, so the current range can be switched while electricity is supplied to the circuit. This also enables remote control via communications outputs.

The output from the A/D converter in the current input and voltage input circuits is sent to the DSP (Digital Signal Processor) via a photo-isolator, which is used to provide insulation between the current input circuit (or voltage input circuit) and the DSP. One DSP is provided for each input element (current/voltage). For instance, a total of 3 DSPs are used for the three-phase, four-wire model (model 253130). The DSP performs averaging of voltage, current and active power for each sampled data sent from the A/D converter. After processing of a certain number of sets of data has been completed, computation of apparent power, reactive power, power factor and phase angle starts.

Computation results are then sent from the DSP to the CPU, where computation such as range conversion, sigma computation and scaling is carried out. Control of display and outputs is also performed by the CPU.

16-bit high-speed A/D converters and 32-bit high-speed DSPs are used to achieve measurement over a wide frequency range, of high accuracy and high speed.



1.3 Functions

Input Functions

Voltage and Current Input Sections

A voltage or current supplied to each input terminal is normalized then sent to the A/D converter, where the voltage or current is converted into a 16-bit digital signal. The digital signal is then sent via photo-isolator to a 32-bit high-speed DSP (Digital Signal Processor) or CPU, where computation of the measured values is carried out.

Frequency Measuring Range

Measurement of DC voltage, current and power as well as AC voltage and current in the frequency range 2 Hz to 200 kHz is possible.

Filter

A filter is used to eliminate harmonic components during measurement of voltage, current, power and frequency of the fundamental harmonic of various waveforms, such as inventer waveforms. This filter can be also used to eliminate noise during measurement of frequencies below 200 Hz.

Wiring Systems

Measurement with the following wiring systems is possible using simple key operation.

Three-phase three-wire model (253120): Single-phase, two-wire; single-phase, three-wire and three-phase, three-wire

Three-phase, four-wire model (253130): Single-phase, two-wire; single-phase, three-wire; three-phase, three-wire; three-phase, four-wire and three-voltage, three-current

Display Functions

This function enables display of measured/computed values using four red high-intensity 7-segment LED displays. A total of four values can be displayed at once.

Computing Functions

This function enables computation of data as specified in Section "14 Specifications", using input voltage and current.

When performing measurements with an external PT, CT and shunt connected, the scaling function is very useful. This function enables display of the measured values in terms of the primary-side values by setting the scaling factor according to the primary/secondary ratio. When this function is used, the active power, apparent power, reactive power and integrated power are multiplied by the scaling factor, then displayed.

An averaging function is also available. This function is used to perform exponential or moving averaging on the measured values before displaying them in cases where the measured values are not stable.

Integrator Functions

This function enables integration of active power and current. During integration, integrated values (power or current), elapsed time of integration and active power can be displayed simultaneously.

Frequency Measurement Functions

This functions enables measurement of the frequency of an input voltage or input current.
Measuring range: 2.0000 Hz to 1000.00 kHz

Harmonic Analysis Functions (Total Harmonic Distortion Function) (Optional)

This enables measurement of up to the 49th harmonic of voltage, current and power, and relative harmonic content for each order, as well as THD (harmonic distortion rate calculated using harmonics up to the 49th harmonic) in accordance with IEC555-2.

External Input/Output Signals (Remote Control Signals and D/A Outputs)

The following functions can be performed using remote controlled input/output signals (contact or logic-level (TTL, active low)).

External Input Signals

$\overline{\text{EXT HOLD}}$

Holds updating of the displayed values or releases the hold status.

$\overline{\text{EXT TRIG}}$

Updates the displayed values in hold mode.

$\overline{\text{EXT START}}$

Starts integration.

$\overline{\text{EXT STOP}}$

Stops integration.

$\overline{\text{EXT RESET}}$

Resets integration.

$\overline{\text{EXT PRINT}}$

Starts printing.

External Output Signals

$\overline{\text{INTEG BUSY}}$

Output when integration is in progress.

$\overline{\text{D/A output (optional)}}$

Outputs measured values (V, A, VA, var, PF, deg, Hz) as a DC analog signal with full scale of ±5V. Output items up to 14 channels can be selected.

Communications Function

Either a GP-IB or RS-232-C interface is provided as standard according to the customer's preference. Measured/computed data can be sent to the personal computer through the interface at a transmission rate of 14 data per 250 ms. It is also possible to control this instrument from the personal computer.

Other Useful Functions

Set-up Information Backup Function

The instrument has a function that backs up the set-up information (including integrated values) in case power is cut off accidentally as a result of a power failure or for any other reason.

Set-up Information Initialization Function

The instrument also has a function that resets the set-up information to the factory settings.

2.1 Checking Package Contents

Unpack the box and check the contents. If any item is missing or does not function properly, contact the dealer from which you purchased the instrument. Inform the dealer of the model name and serial no. specified on the name plate on the rear panel.

Models

Model	Basic Specifications
253120	Capable of measurement for single-phase, two-wire; single-phase, three-wire, and three-phase, three-wire systems.
253130	Capable of measurement for single-phase, two-wire; single-phase, three-wire; three-phase, three-wire; three-phase, four-wire and three-voltage, three-current systems.

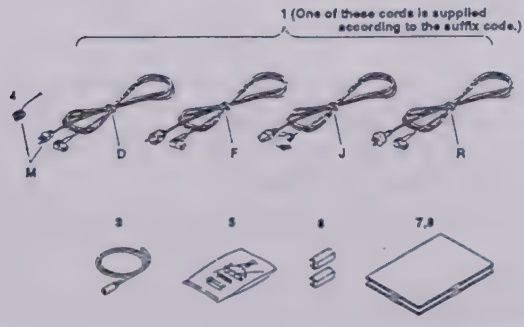
Suffix Codes

Suffix Code	Description
–C1	GP-IB interface
–C2	RS-232-C interface
–1	Rated AC line voltage: 100 VAC
–3	Rated AC line voltage: 115 VAC
–5	Rated AC line voltage: 200 VAC
–7	Rated AC line voltage: 230 VAC
–M	UL/CSA standard power cord (with a 3-pin to 2-pin adapter)
–D	UL/CSA standard power cord
–F	VDE standard power cord
–R	SAA standard power cord
–J	BS standard power cord
/B5	Printer incorporated
/HRM	Harmonic analysis function incorporated
/DA	D/A outputs (14 channels)

Standard Accessories

The following standard accessories are supplied with the instrument.

No.	Name	Part No.	Quantity	Remarks
1	Power cord	Refer to the suffix code.	1	Type of cord is specified by the suffix code.
2	Spare fuse (supplied in the fuse holder)	A1423EF	1	For 100 VAC range type (250 V/1.25 A)
		A1452EF		For 200 VAC range type (250 V/0.63 A)
3	Connector for external shunt	B9293LQ	2 or 3	1 for each element
4	3-pin to 2-pin adapter	A1253JZ	1	Supplied only for "–M" model
5	36-pin connector	A1005JD	1	For remote control and D/A outputs
6	Roll chart	B9293UA	2	For built-in printer (optional), 58 mm × 10 m
7	User's Manual	IM253120-01E	1	This manual
8	User's Manual	IM253110-51E	1	For harmonic analysis (optional)



2.2 Usage Precautions

General Handling Precautions

Observe the following precautions when handling the instrument.

- Never place anything on top of the instrument, especially objects containing water. Entry of water into the instrument may result in breakdowns.
- Observe the following precautions when moving the instrument.
  Disconnect the power cords and connecting cables.
  Always carry the instrument by the handles as shown below.

- To prevent internal temperature rise, do not block the vent holes in the instrument case.
- Keep input terminals away from electrically charged articles as they may damage internal circuits.
- Do not allow volatile chemicals to come into contact with the case or operation panel. Also do not leave any rubber or vinyl products in contact with them for prolonged periods. Doing so may result in breakdowns.
- The operation panel is made of thermoplastic resin, so take care not to allow any heated articles such as a soldering iron to come into contact with it.
- If the instrument will not be used for a long period, unplug the power cord from the AC outlet.

Safety Precautions

- Do not remove the case from the instrument.
  Some areas in the instrument use high voltages, which are very dangerous.
  When the instrument needs internal inspection or adjustment, contact your dealer or nearest YOKOGAWA representative.
- If you notice smoke or unusual odors coming from the instrument, immediately turn OFF the power and unplug the power cord. Also turn OFF the power to all the objects being measured that are connected to the input terminals. If an such irregularity occurs, contact your dealer or the nearest YOKOGAWA representative.
- If you use a 3-pin to 2-pin adapter to connect the power cord to a 2-pin AC outlet, make sure that the grounding wire of the adapter is grounded properly. For details, refer to page 2-5. The part no. of the adapter is "A1253JZ".
- Do not place anything on the power cord. Also keep it away from any heat generating articles. If the power cord is damaged, contact your dealer or nearest YOKOGAWA representative.
- When unplugging the power cord from the AC outlet, never pull the cord itself. Always hold the plug and pull it.

Storage Area

Never store the instrument in places where it may be exposed to any of the following conditions.

- Relative humidity of 80% or higher
- Direct sunlight
- Temperature of 40°C or higher.
- Proximity to any high-temperature heat sources
- Excessive vibration
- Corrosive or flammable gases
- Excessive amount of dust, dirt, salt or iron filings
- Splashes of water, oil or chemicals

2.3 Installing the Instrument

Installation Conditions

The instrument must be installed in a place where the following conditions are met.

- **Ambient temperature and humidity**

  Ambient temperature: 5 to 40°C

  Ambient humidity: 20 to 80% RH (no condensation)

- **Well-ventilated place**

  Vent holes are provided on the top and bottom of the instrument. To prevent rise in internal temperature, do not block these vent holes.

Note

- To ensure high measurement accuracy, the instrument should only be used under the following conditions.

  Ambient temperature: 23 ±5°C

  Ambient humidity: 30 to 75% RH (no condensation)

  When using the instrument in the temperature ranges of 5 to 18 or 28 to 40°C, multiply the measured values by the temperature coefficient specified in Section "14 Specifications."
- If the ambient humidity of the installation site is 30% or below, use an anti-static mat to prevent generation of static electricity.
- Internal condensation may occur if the instrument is moved to another place where both ambient temperature and humidity are higher, or if the room temperature changes rapidly. In such cases acclimatize the instrument to the new environment for at least one hour before starting operation.

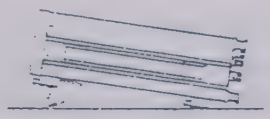
Never install the instrument in the following places.
Otherwise, the internal circuits and the case may be affected adversely, hindering accurate measurement.

- In direct sunlight or near heat sources
- Where an excessive amount of soot, steam, dust or corrosive gases is present.
- Near magnetic field sources
- Near noise sources such as high voltage equipment or power lines
- Where the level of mechanical vibration is high
- In an unstable place

Installation Position

Desktop Installation

Place the instrument in a horizontal position or tilted using the stand as shown below.



Rack Mount

To install the instrument in a rack, use one of the following optional rack mount kits.

Rack mount kit (optional)

Kit Name	Model	Standard
Rack mount kit	751531	EIA
Rack mount kit	751532	JIS

Mounting Procedure

1. Remove the seal cover from the mounting holes on both sides of the instrument. (Four seal covers in total)
2. Attach the mount kit as shown below.
3. Remove the four legs from the bottom of the instrument.
4. Remove the handle from each side of the instrument.
5. Cover each handle mount hole with a seal.
6. Mount the instrument in the rack.
   - When mounting the instrument, support it from underneath.
   - Refer to Section "14 Specifications" for rack mounting dimensions.

2.4 Power Supply Connection

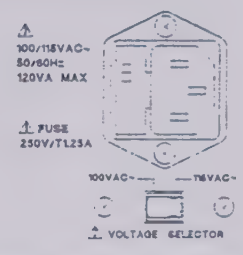
Power Supply Requirements and Voltage Selector Switch

The instrument can be operated with a power supply voltage of between 100 and 115 VAC or between 200 and 230 VAC.

Rated supply voltage	: 100 VAC	115 VAC	200 VAC	230 VAC
Permitted supply voltage range	: 90 to 110 VAC	100 to 132 VAC	180 to 220 VAC	198 to 264 VAC
Rated supply voltage frequency	: 50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Permitted supply voltage frequency range	: 48 to 63 Hz	48 to 63 Hz	48 to 63 Hz	48 to 63 Hz

Setting the voltage selector switch

Check whether the voltage selector switch on the rear panel is set properly according to the suffix code (page 2-1). If not, set it correctly.



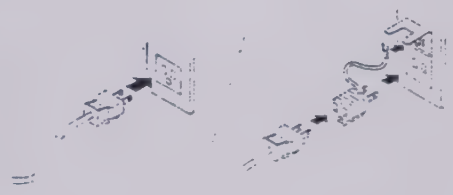
⚠ CAUTION

- If you have changed the original voltage setting, make sure that both the power supply fuse and power cord are appropriate for the newly selected voltage before using the instrument.
- When checking the power supply fuse, refer to Section "13.3 Replacing the Power Supply Fuse" (page 13-4).
- When checking the power cord, refer to the ratings specified in the suffix code in Section "2.1 Checking Package Contents" (page 2-1).

Connecting the Power Cord

⚠ WARNING

- If the AC outlet is a 2-pin type, use the 3-pin to 2-pin adapter supplied with the instrument. Be sure to connect the grounding wire (green) of the adapter to the grounding terminal of the AC outlet.
- Before plugging in the power cord, make sure that the voltage of the AC outlet is within the specified range.



- To prevent electric shock or fire, use only the 3-pin to 2-pin adapter supplied by YOKOGAWA.
- Never use an extension cord without a grounding wire, otherwise the protection feature will be invalidated.

2.5 Turning the Power ON or OFF

Items to be Checked Before Turning ON the Power

- Check that the instrument is installed correctly as instructed in Section "2.3 Installing the Instrument" (page 2-3).
- Check whether the power supply voltage from the AC outlet matches the one selected by the voltage selector switch.

Location of the Power Switch

The power switch is located in the lower left corner of the front panel.

Turning Power ON/OFF

A pushbutton switch is used as the power switch. The power is turned ON and OFF alternatively as the switch is pressed.

Note

- The instrument uses a lithium battery that backs up set-up information and the date and time entered from the operation panel.
- A warm-up time of approximately 30 minutes is required before all specifications of the instrument are met.

Response and Display at Power ON

The test program starts when the power switch is turned ON. The test program checks each memory. If the check results are satisfactory, opening messages will appear as shown on page 2-8, and the instrument is ready for measurement.

If error code appears at the end of the test program, the instrument is not functioning properly. In this case, turn OFF the power immediately, and contact your dealer or the nearest YOKOGAWA representative. Inform them of the model name and serial no. specified on the name plate on the rear panel, as well as the error code that was displayed.

Note

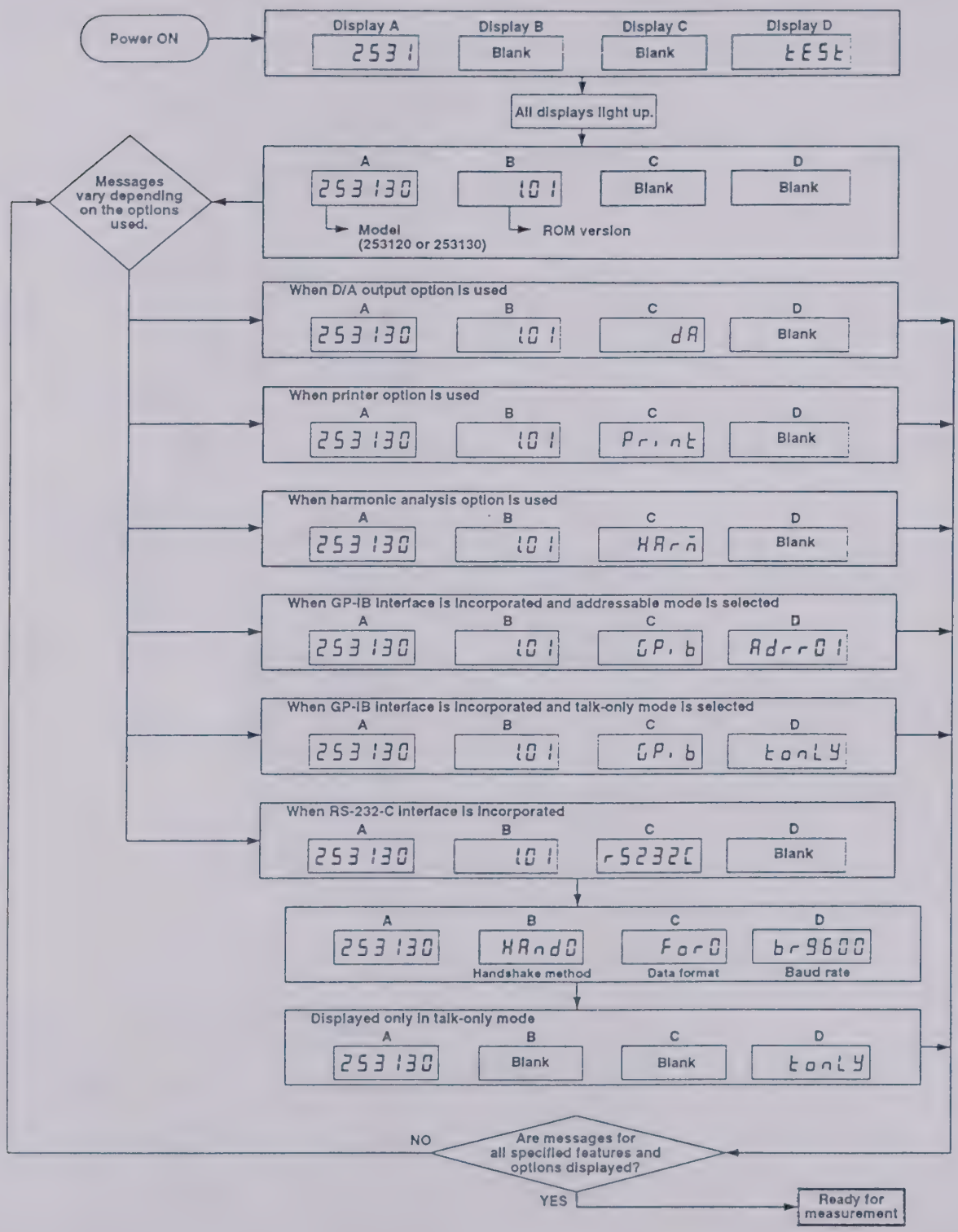
- In the case of an error code, refer to Section "13.2 Error Codes and Corrective Actions" (page 13-2), and carry out the specified corrective actions.

Default Settings (Factory Initialization Settings)

	Display	Factor	LED
Display	A	V1	1, V
	B	A1	1, A
	C	W1	1, W
	D	W1	1, W
Measuring range	VOLTAGE	600 V	600 V
	AMP	30 A	30 A
	Shunt scaling value	50.000A	
Measurement mode	RMS/MEAN/DC	RMS	RMS
Measuring conditions	Wiring system	1ø2W	1ø2W
	Hold	OFF	
	Sample rate	MID	MID
	Scaling	OFF	OFF
	Averaging	OFF	
	Filter	OFF	
	Crest factor	3	CF3
	Integration	Invalid	
	Harmonic analysis (optional)	OFF	
	Frequency	VHz	
	MATH	Efficiency (EFF 1)	
Scaling constant	Kv	1.0000	
	Ki	1.0000	
	Kw	1.0000	
Averaging	Averaging method	Exponential averaging (EP)	
	Attenuation constant	8	
Integration	Integration mode	Standard integration mode (nor)	
	Integration timer	0 hour 0 minute	
Communications			
Command group	Used to select scaling value setting method (whether scaling value is set at once for all elements or set one by one for each element) as well as to select 2531 or 2533E command groups.	CM0	
GP-IB	Address	1	
	Addressable mode	A	
	Status byte	15	
	Delimiter	0	
RE-232-C	Normal mode		
	Handshake mode	0	
	Format	0	
	Baud rate	9600	
	Delimiter	0	
	Status byte	15	
Common	Communications output/print Output function	dFLt-n	
Harmonic analysis (optional)	PLL source	V1	
	Display format	Format 1 (For0)	
Printer (optional)	Auto print	OFF	
	Print interval	1 minute	
D/A output (optional)	D/A output	dFLt-n	
	Rated integration time for D/A output	1 hour 0 minutes	

Opening Messages

When the power switch is turned ON, the following messages will appear. The messages vary depending on the options used.



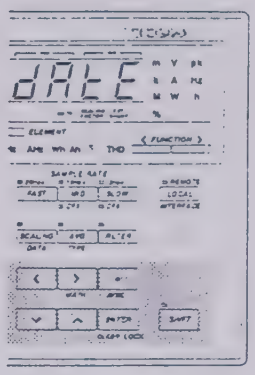
2.6 Setting the Date and Time

Setting the Date/Time Mode

Mode Setting

1. Press the *MISC* key (*SHIFT* + ▫).
   Keep pressing the ∧ or ∨ key until "dAtE" appears on display D.

2. Press the *ENTER* key.
   "dAtE" moves to display A, and the date and time currently set appear on displays C and D respectively.
   The leftmost digit of display C (date) starts blinking.



Display A	Display B	Display C	Display D
dAtE		93.12.05	10.23.55
		Y M D	H M S

Setting the Date and Time

3. Set the desired value for the blinking digit using the ∧ or ∨ key. Press the < or > key to move to another digit and set a value. Repeat this step until the entire date has been set.

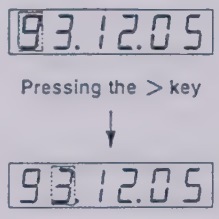
4. When the entire date has been set, press the *ENTER* key. This causes the leftmost digit of display D (time) to start blinking. Repeat step *3* to set the desired time.

5. When the time has been set, press the *ENTER* key. The timer begins to operate.

Shifting the Blinking Position

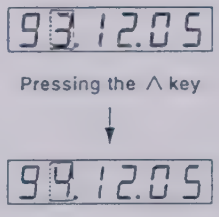
The blinking position can be shifted to the left or right by pressing the < or > key.
Pressing the < key causes the digit to the left of the currently blinking digit to blink, and pressing the > key causes the digit to the right of the currently blinking digit to blink.
The blinking position wraps around in both directions.

Display



Setting a Value

To set a value for the blinking digit, press the ∧ or ∨ key.
Pressing the ∧ key changes the value according to the sequence 1, 2, 3 ... 9, 0 and back to 1.
Pressing the ∨ key changes the value in the opposite direction.



3.1 Wiring Precautions

⚠ **WARNING**

- To prevent hazards, a protective grounding connection must be made as follows. The power cord supplied with the instrument has a 3-pin plug. One of the three pins is used for grounding. The power cord must be connected to a 3-pin AC outlet (including a grounding terminal). If you are using a 3-pin to 2-pin adapter, connect the grounding wire of the adapter to the grounding terminal of the AC outlet.
- Always turn OFF the power to the object being measured, before connecting it to the instrument. Never connect or disconnect the measurement lead wires from the object while power is being supplied to it, otherwise a serious accident may result.
- Be sure that you do not connect a current circuit to the voltage input terminal or vice versa. Incorrect connection may cause damage not only to the circuit or equipment under test and to this instrument, but may also endanger the operator.
- Never apply a voltage or current exceeding the level specified in the table below to the voltage input terminal or current input terminal, no matter whether the power switch is ON or OFF.

Permissible Maximum Input	Voltage Input	Current Input
Maximum Instantaneous Input (for one second)	Peak voltage of 3.5 times the measuring range or 1,400 V whichever is lower	Peak current of 10 times the measuring range or 60 A, whichever is lower Peak current of 20 times the measuring range or lower in the case where an external shunt is used
Maximum Continuous Input	Peak voltage of 1,000 V or rms voltage of twice the measuring range, whichever is lower	Peak current of 5 times the measuring range or rms current of twice the range, whichever is lower. (However, current should not exceed 35 A.) Peak current of 10 times the measuring rage or lower in the case where an external shunt is used

- If you want to use an external current transformer (CT), use one which has a sufficient withstand voltage against the voltage to be measured. (A withstand voltage of 2E + 1000V is recommended, where E is the measurement voltage.) Also be sure not to allow the secondary side of the CT to go open-circuit while power is supplied, otherwise an extremely dangerous high voltage will be generated on the secondary side of the CT.
- If the instrument is used in a rack, provide a power switch so that power to the instrument can be shut off from the front of the rack in an emergency.
- For safety reasons, make sure that the bare end of the measurement lead wire connected to each input terminal does not protrude from the terminal. Also make sure that the measurement lead wires are connected to the terminals securely.

⚠ **CAUTION**

- The lead wires must have a sufficient margin in both withstand voltage and current against those to be measured. They must also have insulation resistance appropriate to their ratings.
  Example: If measurement is carried out on a current of 30 A, use copper wires with a conductor cross-sectional area of at least 8 mm².

Note

- After completion of the wiring, the ***WIRING*** key needs to be used to select the wiring system before starting measurements. Refer to Section "3.2 Setting Wiring System" (page 3-2) for a description of the procedures.
- When measuring high currents, or currents or voltages that contain high-frequency components, wiring should be made with special attention paid to possible mutual interference and noise problems.
- Keep the lead wires as short as possible.
- For current circuits indicated by thick lines in the wiring diagrams shown in Section 3.3 (page 3-4 and subsequent pages), use thick lead wires appropriate for the current to be measured.
- The lead wire to the voltage input terminal should be connected as close to the load of the object under measurement as possible.
- To minimize stray capacitance to ground, route both lead wires and grounding wires so that they are as away from the instrument's case as possible.

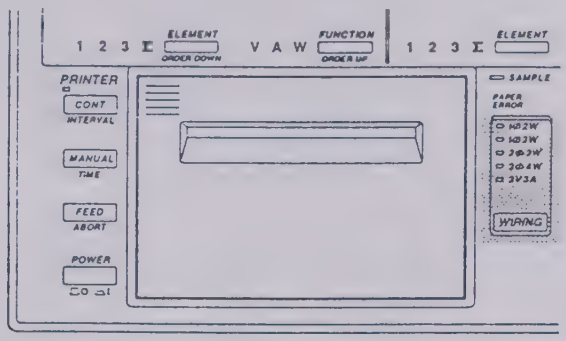
3.2 Setting Wiring System

Precautions

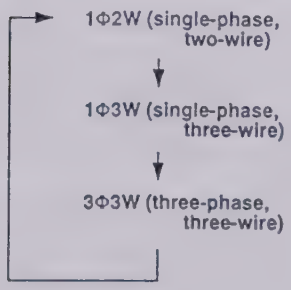
Make sure that the wiring system that matches the actual wiring is selected, otherwise a measurement error will occur. (Computation method varies according to the wiring system.)

Setting Wiring System

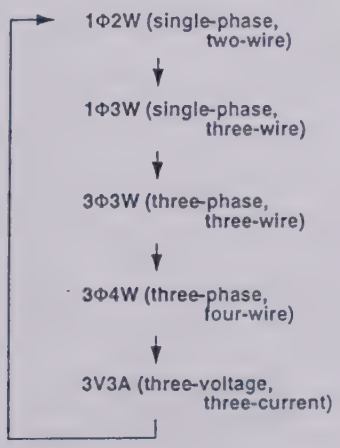
The wiring system is selected in the sequence shown below each time the *WIRING* key is pressed. The LED for the selected wiring system lights up.
Select the wiring system type that matches the one you have assembled.



Three-phase, three-wire model (253120)



Three-phase, four-wire model (253130)



Note

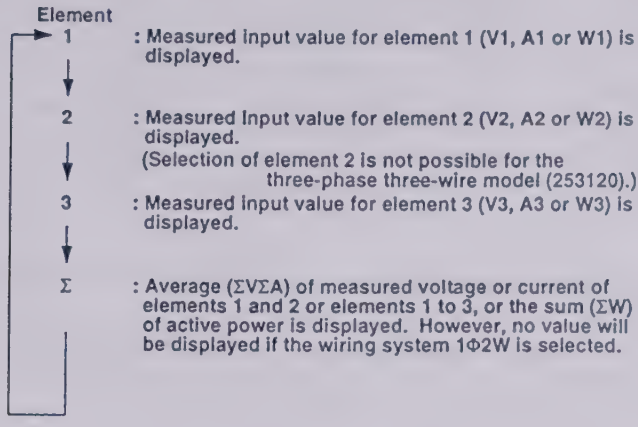
- When measuring apparent power, reactive power, power factor, phase angle or efficiency, selecting a wiring system different from the actual wiring system connected to the input terminals hinders accurate measurement. Make sure that the correct wiring system is selected.
- Selectable wiring systems differ from model to model. Refer to "Wiring System Setting and Selectable Measuring Objects (Elements)" on the next page.

Setting Element

Element selection can be performed for each display. Press the *ELEMENT* key located below each display to select a desired element.

Elements are selected in the following sequence as the *ELEMENT* key is pressed.

The default setting is "Element 1."


Element
1
: Measured input value for element 1 (V1, A1 or W1) is displayed.
2
: Measured input value for element 2 (V2, A2 or W2) is displayed.
(Selection of element 2 is not possible for the three-phase three-wire model (253120).)
3
: Measured input value for element 3 (V3, A3 or W3) is displayed.
Σ
: Average (ΣVΣA) of measured voltage or current of elements 1 and 2 or elements 1 to 3, or the sum (ΣW) of active power is displayed. However, no value will be displayed if the wiring system 1Φ2W is selected.

Note

- Display A is shown in the above figure as an example.
  Refer to Section "14 Specifications" for the equation for each measurement item.

Wiring System Setting and Selectable Measuring Objects (Elements)

The table below shows elements which can be measured with the wiring system selected with the *WIRING* key.

Model	Wiring System	Element
253120	1ø2W	1, 3
	1ø3W	1, 3, Σ
	3ø3W	1, 3, Σ
253130	1ø2W	1, 2, 3
	1ø3W	1, 2, 3, Σ
	3ø3W	1, 2, 3, Σ
	3ø4W	1, 2, 3, Σ
	3V3A	1, 2, 3, Σ

3.3 Wiring the Measurement Circuit

The table below gives a list of wiring examples (diagrams) for each wiring system.

Wiring System		1ø2W	1ø3W	3ø3W	3ø4W	3V3A
Wiring System	*WIRING* key	1ø2W	1π3W	3π3W	3ø4W	3V3A
Wiring Diagram	When an input is applied directly	Fig. 3.1	Fig.3.2	Fig. 3.3	Fig. 3.4	Fig. 3.5
	When PT and CT are used (page 3-8)	Fig. 3.8	Fig. 3.9	Fig. 3.10	Fig. 3.11	Fig. 3.12
	When an external shunt is used (page 3-10)	Fig. 3.15	Fig. 3.16	Fig.3.16	Fig. 3.17	Omitted

Wiring Method when Voltage and Current are Applied Directly

Fig. 3.1 Wiring Diagram for Single-Phase Two-Wire (1ø2W)

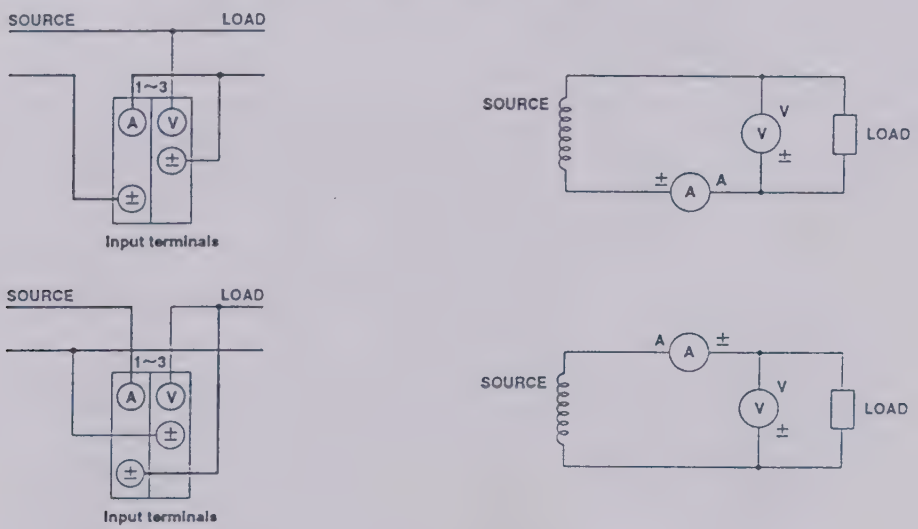
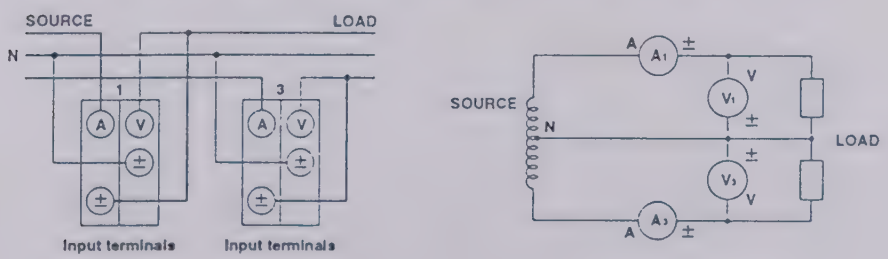


Fig. 3.2 Wiring Diagram for Single-Phase Three-Wire (1ø3W)



WARNING When applying a current to be measured directly to the input terminals of the instrument, make sure that the external shunt cable is not connected to the instrument.

CAUTION A load current flows in the thick lines shown in the diagrams, therefore a wire with sufficient current capacity must be used for these lines. The wire connected from the source to the ± current terminal must be routed as close as possible to the ground potential in order to minimize measurement error. (Refer to "Note" on page 3-6.)

Fig. 3.3 Wiring Diagram for Three-Phase Three-Wire (3ø3W)

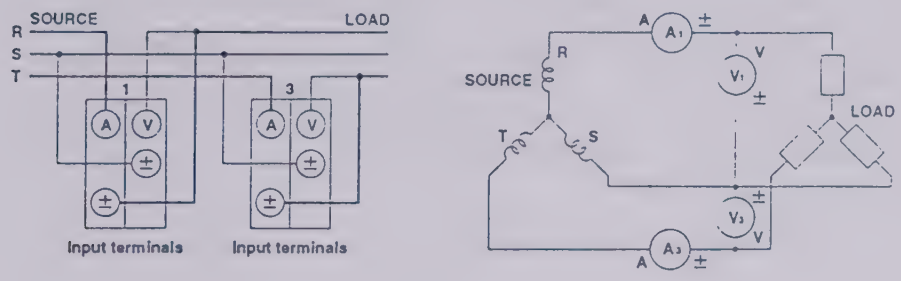


Fig. 3.4 Wiring Diagram for Three-Phase Four-Wire (3ø4W)

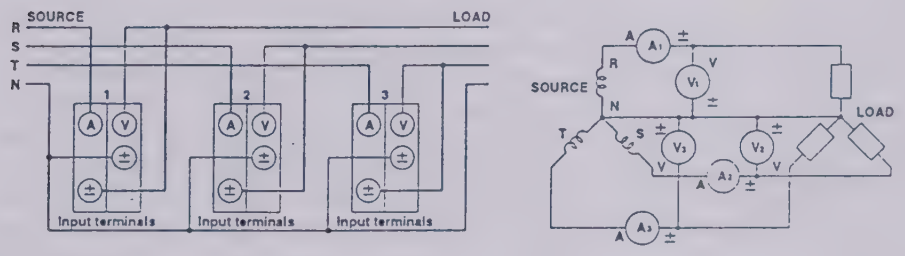
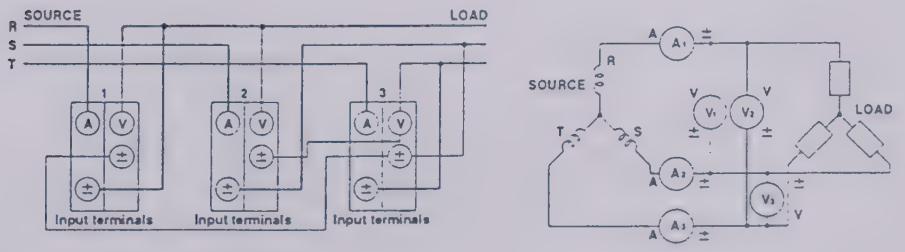


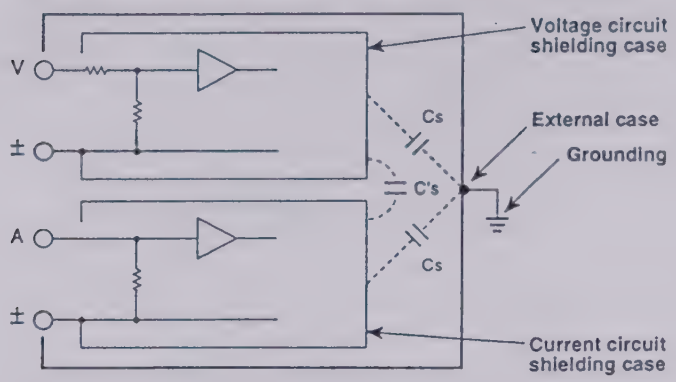
Fig. 3.5 Wiring Diagram for Three-Voltage Three-Current (3V3A)



Note

- The wire connected from the source to the ± current terminal must be routed as close as possible to the ground potential in order to minimize measurement error. Fig. 3.6 shows the input circuit diagram of the instrument.

Fig. 3.6 Input Circuit of the Instrument

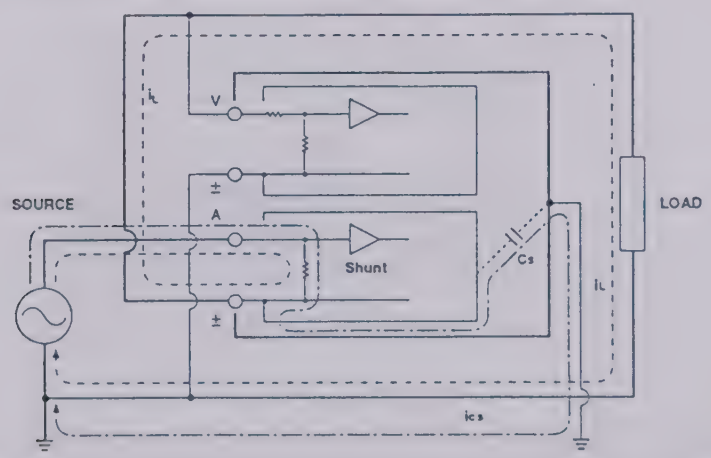


The voltage circuit is enclosed in its own shielding case, and the current circuit is also enclosed in its own shielding case. Both shielding cases are then enclosed in the external case. The voltage circuit shielding case is connected to the ± voltage terminal, whilst the current circuit shielding case is connected to the ± current terminal.

Although insulation is provided between the shielding cases as well as between the external case and each shielding case, stray capacitance Cs and C's are still present. Cs is approximately 100 pF. With power meters such as this instrument that are capable of measurement of current, voltage etc. of high frequency, these stray capacitance cannot be ignored as they cause measurement errors.

As an example, let's imagine the circuit shown in Fig. 3.7, where one end of the SOURCE (power source) and the external case are grounded. Current i_L from the power source enters the current terminal (A), passes the shunt, comes out from the current terminal (±), then returns via the LOAD (load) to the power source, as indicated by the dotted line. The other route (i_{cs}) is indicated by the dashed line; from the power source, through the shunt, stray capacitors, external case grounding, and power source grounding.

Fig. 3.7



From this, it is obvious that the sum (vector sum) of the load current i_L and i_{cs}, which flows through the stray capacitors, is always measured even though we want to measure load the current i_L only. The current i_{cs}, which flows through the stray capacitor Cs, is calculated as follows.

$$i_{cs} = V_{cs} \times 2\pi f \times Cs$$

Where, the common-mode voltage applied to Cs is V_{cs}

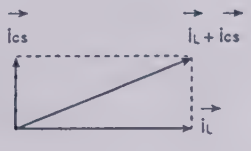
In the circuit shown in Fig. 3.1, no measurement error will occur since V_{cs} is zero because both current terminal (±) and voltage terminal (±) are close to the ground potential.
Effects of the stray capacitance are calculated below for reference.

$C_s = 100\ pF = 100 \times 10^{-12} F = 10^{-10} F$
Therefore,
$i_{cs}[A] = V_{cs}[V] \times 2\pi f[H] \times C_s = V_{cs} \times 2\pi f \times 10^{-10}$
$= 2\pi \times 10^{-4} \times V_{cs} \times f[kHz]\ [mA]$

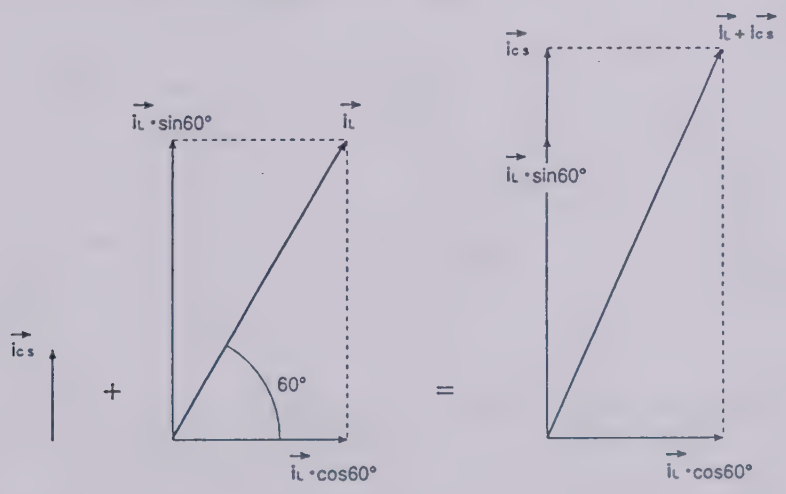
Assuming f = 100 kHz and V_{cs} = 100 V, $i_{cs} \neq 6.28$ mA
If i_L = 1 A, the current is expressed as a vector sum, as below, where the load consists of resistance only (i.e. COSφ = 1),

$$\left| \vec{i_L} + \vec{i_{cs}} \right| = \sqrt{1^2 + 0.00628^2}$$
$$\fallingdotseq 1.00002\ A$$

Therefore, the measurement error is 0.002%, indicating that the effect on the measurement of the stray capacitance is very slight.



If COSφ = 0.5, the current can be obtained as follows.



$$\left| \vec{i_L} + \vec{i_{cs}} \right| = \sqrt{(i_L\cos 60°)^2 + (i_{cs} + i_L\sin 60°)^2}$$
$$= \sqrt{(0.5)^2 + (0.00628 + 0.866)^2}$$
$$\fallingdotseq 1.00542\ A$$

Therefore, the measurement error is 0.542%.
If COSφ = 0, $i_L + i_{cs}$ = 1 + 0.00628 = 1.00628, therefore, the measurement error is 0.628%.
Since active power is obtained using the equation W = VA COSφ, the error is the same as that in the measurement of the current.

Wiring Method when PT and CT are Used

Use of a PT (or CT) enables measurement of voltage or current even if the maximum voltage or maximum current of the object to be measured exceeds the maximum measuring range.

- If the maximum voltage of the object to be measured exceeds 600 V, connect an external potential transformer (PT), and connect the secondary side of the PT to the voltage input terminals.
- If the maximum current of the measuring object exceeds 30 A, connect an external current transformer (CT), and connect the secondary side of the CT to the current input terminals.
  In the diagram below, the thick lines represent the current circuit, and the thin lines represent the voltage circuit.

Fig. 3.8 Wiring Example for Single-Phase Two-Wire (1ø2W) System with PT and CT Connected

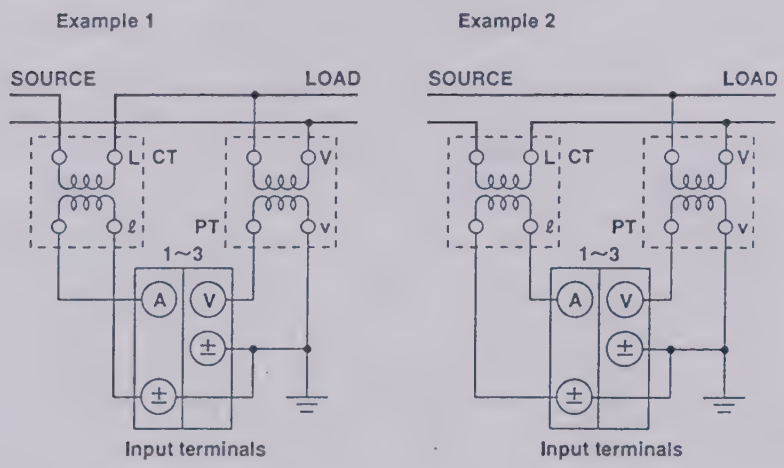
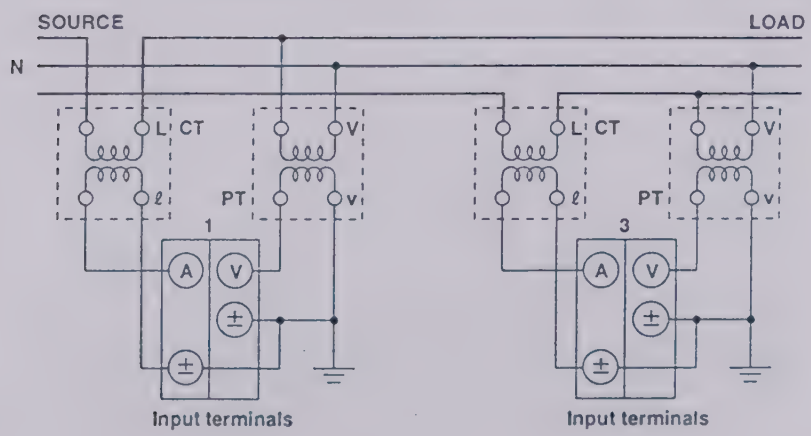


Fig. 3.9 Wiring Example for Single-Phase, Three-Wire (1ø3W) System with PT and CT Connected



WARNING

When using an external CT, do not allow the secondary side of the CT to go open-circuit while power is supplied, otherwise an extremely dangerous high voltage will be generated on the secondary side of the CT.

Note

- Use of the scaling function enables direct reading of measured values on the display. For a description of how to set the scaling function, refer to Section "8.4 Using the Scaling Function" (page 8-7).
- It must be noted that measured values are affected by the frequency and phase characteristics of PT and CT.

Fig. 3.10 Wiring Example for Three-Phase, Three-Wire (3ø3W) System with PT and CT Connected

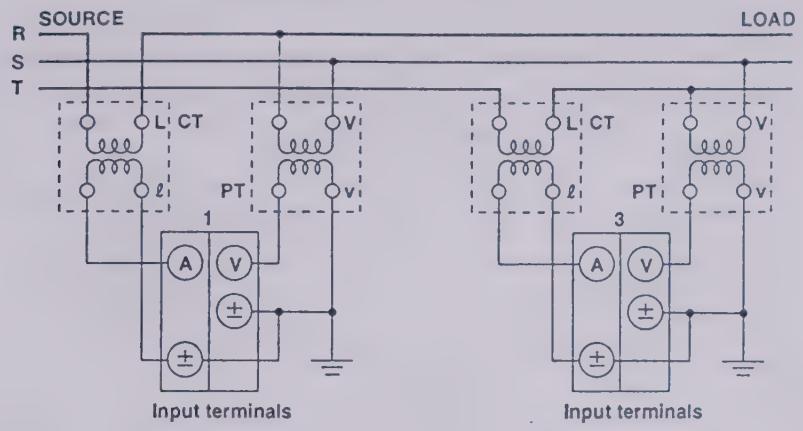


Fig. 3.11 Wiring Example for Three-Phase, Four-Wire (3ø4W) System with PT and CT Connected

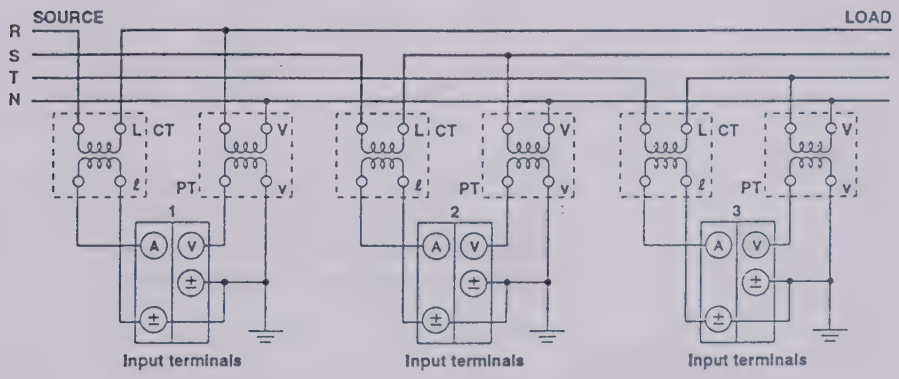
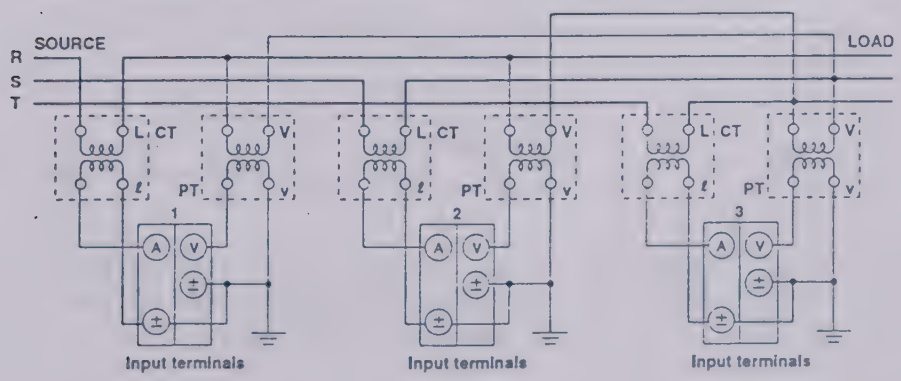


Fig. 3.12 Wiring Example for Three-Voltage, Three-Current (3V3A) System with PT and CT Connected

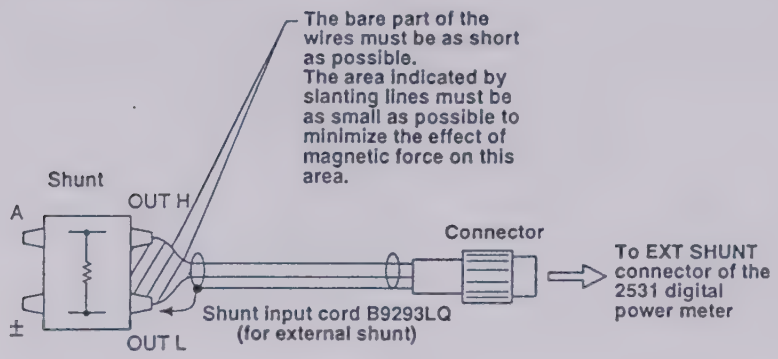


Wiring Method when External Shunt is Used

In cases where the maximum current of the object to be measured exceeds 30 A, connect a shunt rated for the desired current to the external shunt input connector. The shunt must have appropriate frequency and phase characteristics.

Connecting an External Shunt to an External Shunt Input Cord

Connect the shielding wire of the cord to the output terminal (OUT L), as shown below, to minimize measurement error.


The bare part of the wires must be as short as possible.
The area indicated by slanting lines must be as small as possible to minimize the effect of magnetic force on this area.
Shunt
A
OUT H
±
OUT L
Connector
To EXT SHUNT connector of the 2531 digital power meter
Shunt input cord B9293LQ (for external shunt)

Connector No.	Wire Color	Signal
1	White	OUT H
2	–	Not used
3	Shielding	wire Shielding
4	Black	OUT L
–	Green	Not used

Since 50, 100 and 200 mV ranges are available for the external shunt, use an external shunt whose voltage drop matches these ranges. If an external shunt that does not match these ranges is used, convert the measured values on the display to input current values using the scaling function. Refer to Section "4.2 Setting Measuring Ranges" (page 4-8).

WARNING

- For safety, use a shunt that is enclosed in a case. Use of a bare shunt may cause an electric shock if the shunt is touched accidentally. If a case is provided separately, the case must have a sufficient withstand voltage against the voltages to be measured.
- The part no. for the external shunt input cord (standard accessory) is B9293LQ. The rated voltage is 300 V (withstand voltage: 1500 V). Do not apply a voltage exceeding these limits, as this may cause accidents as well as measurement errors.
- Before connecting an external shunt, make sure that the power to the shunt is turned OFF.
- A voltage is present on the external shunt while power is supplied to it, so do not touch the shunt with your hands.
- Do not connect anything to the input current terminals (A, ±) of the instrument, otherwise damage to the instrument or personnel injury may result.

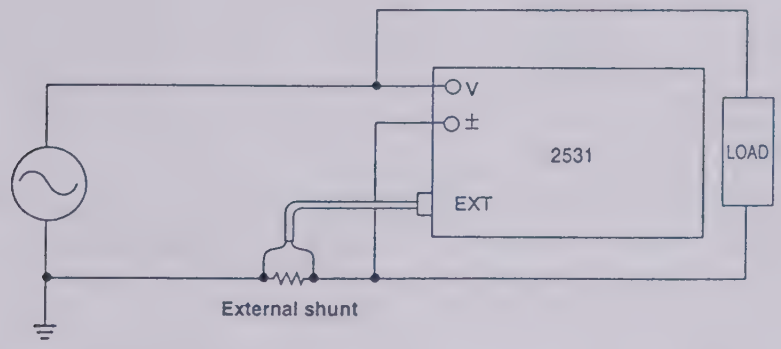
CAUTION

- Keep the distance from the measurement point to the shunt as short as possible. If this distance is too long, stray capacitance or wiring impedance will increase, causing measurement error.

Note

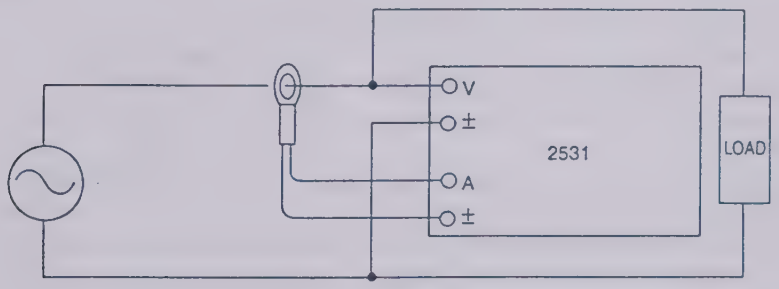
- The external shunt must be selected carefully and its frequency and phase characteristics taken into account.
- The external shunt must be wired so that the area between the wires connected to both ends of the shunt is minimized, in order to reduce the effect of the magnetic field generated by the current to be measured. Measurement is affected by magnetic field lines entering this area. Minimizing this area also reduces the effects of external noise.
- To avoid the effects of common-mode voltage, the external shunt must be connected to the grounding side of the power source.

Fig. 3.13



- If the measuring object is high frequency and high power and is not grounded, the effects of inductance present on the shunt connecting cable will be increased. In this case, use an isolation sensor (CT, DC-CT, clamp).

Fig. 3.14



- For safety, use a shunt that is enclosed in a case. Use of a bare shunt may cause an electric shock if the shunt is touched accidentally. If a case is provided separately, the case must have a sufficient withstand voltage against the voltages to be measured. However, this requirement does not need to be met if the shunt is connected to the grounding side of the power source as shown in Fig. 3.13, the single-phase, two-wire system.

Fig. 3.15 Wiring Example for Single-Phase, Two-Wire (1ø2W) System with Shunt Connected

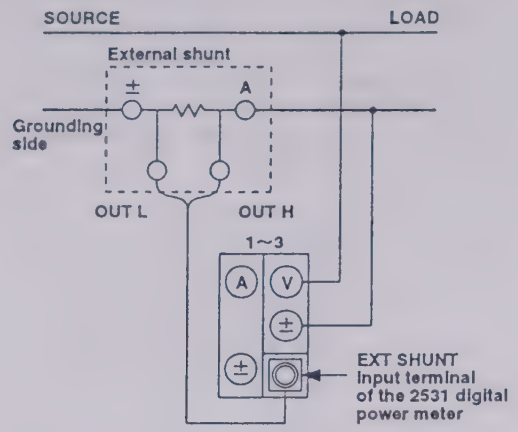


Fig. 3.16 Wiring Example for Single-Phase, Three-Wire (1ø3W) or Three-Phase, Three-Wire (3ø3W) System with Shunt Connected

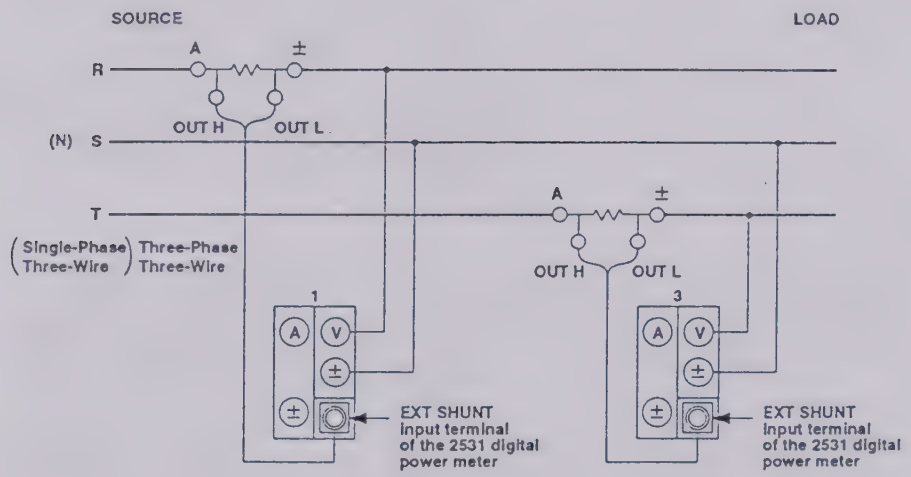
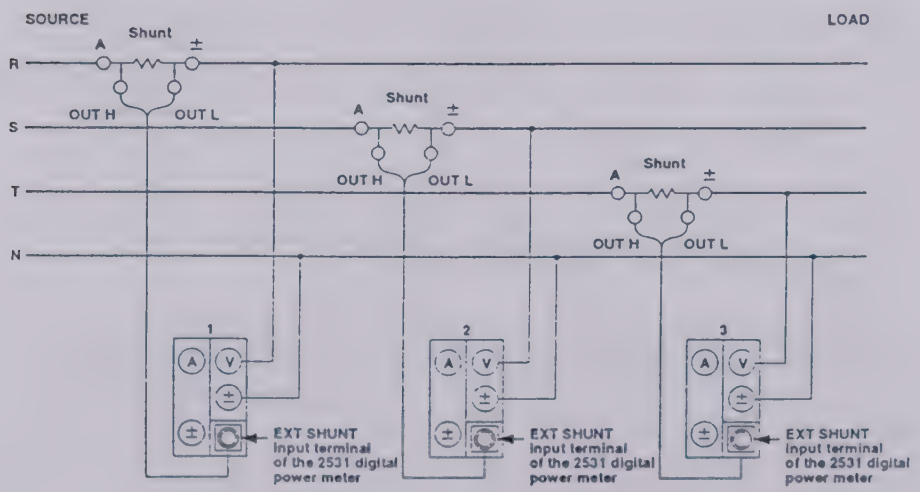


Fig. 3.17 Wiring Example for Three-Phase, Four-Wire (3ø4W) System with Shunt Connected



3.4 Improving Measurement Accuracy

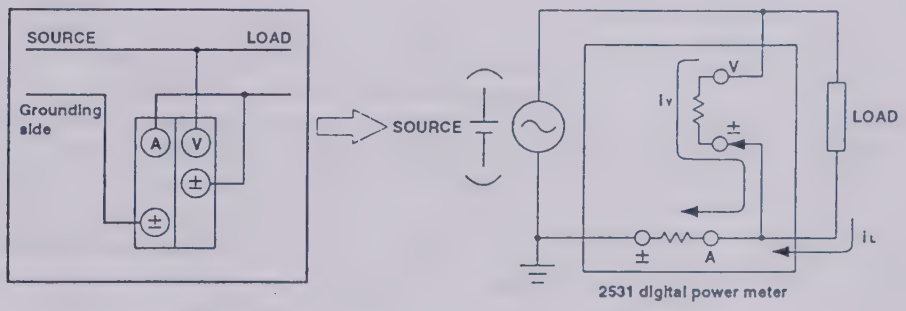
Recommended Wiring Method

This instrument is designed so that voltage input impedance is high and current input impedance is low to reduce the effect of instrumental loss on measurement accuracy.

Voltage input impedance:	Approximately 2 MΩ (all ranges), with a capacitance of approximately 15 pF connected in parallel
Current input impedance:	Approximately 6 mΩ + 0.07 μH (all ranges)

The following wiring (indicated on the top of the instrument) is recommended.

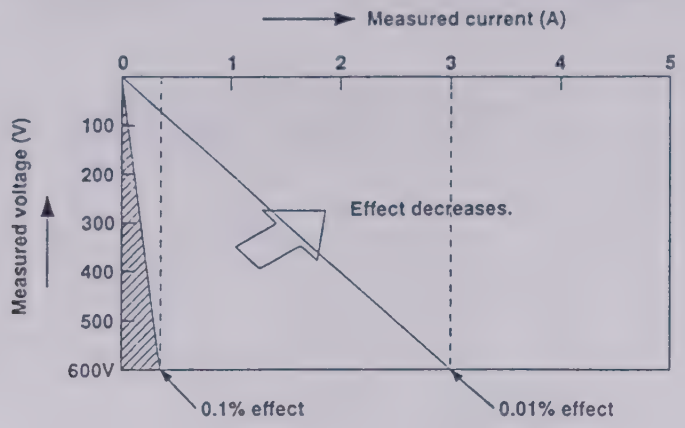
Fig. 3.18



In the above diagram, the voltage measurement circuit is connected to the load side. The effects of instrumental loss on measurement accuracy are explained below. To simplify understanding, it is assumed that a DC power source and resistive load are used. The current measurement circuit measures the sum of the current i_L that flows to the load (object being measured) and the current iv that flows to the voltage measurement circuit. This means that the current iv is erroneous since the current to be measured is i_L.

Since the input impedance of the voltage measurement circuit is high (approximately 2 MΩ), and even if the input voltage is 600 V iv becomes approximately 0.3 mA (= 600 V/2 MΩ). If the instrumental error is assumed to be below 0.1%, the measured current (i_L) will be 300 mA or higher (load resistance: 2 kΩ or lower). If the input voltage is 10 V, i_L is 5 mA or higher. The relationship between the input voltage and the measured current in cases where instrumental error is within 0.1% and 0.01% is given on the next page as a reference.

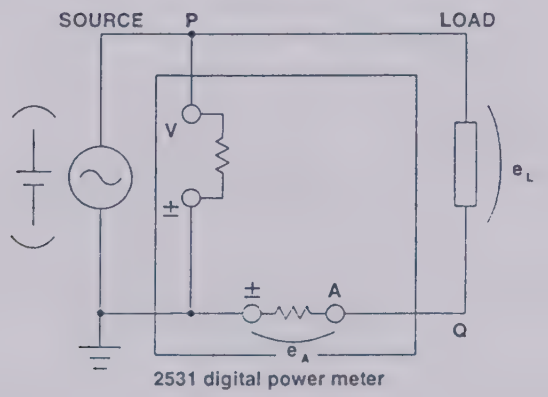
Fig. 3.19 Effects of Instrumental Error



In many cases the recommended wiring method is suitable. For instance, when the input voltage and current are 100 V and 5 A, iv is 0.05 mA (= 100 V/2 MΩ), therefore the effect on measurement accuracy is 0.001% (= 0.05 mA/5 A), which is low.

On the other hand, measurement accuracy is significantly affected when the measured current is low (i.e. high load resistance). In this case, make the connections as follows so that the current measurement circuit is located on the load side. The voltage measurement circuit measures the sum of the voltage drop e_L at the load and e_A at the current measurement circuit, therefore e_A is erroneous. However, the effect of this error is small since the input impedance of the current measurement circuit is low. For instance, if the load resistance is 600 Ω, the input impedance is approximately 6 mΩ, therefore the error in measurement is approximately 0.001% (= $e_A/(e_L + e_A)$), which is low.

Fig. 3.20



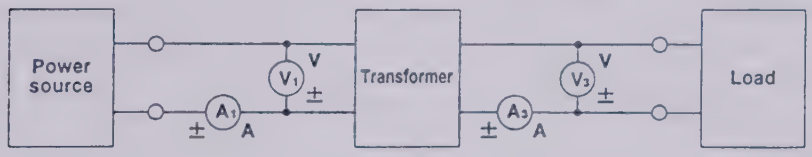
From the above explanation, it can be understood that the effect of instrumental loss on measurement accuracy can be reduced by wiring according to the load resistance.

3.5 Wiring System and Equations of Efficiency

Pay attention to the following when measuring efficiency.
Measurement of efficiency is possible only with the following wiring systems. Make sure that the input element no. matches the affix no. (for instance, "1" of W1) of the variable used in the equation.

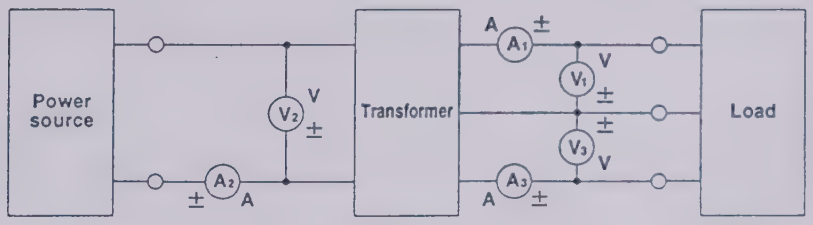
Wiring Systems and Equations

Two-wire system for both input and output: Select 1ø2W, 1ø3W (for 253120 only) or 3ø3W (for 253120 only).



Equation: $\eta = \frac{W3}{W1} \times 100\ (\%)$

Single-phase for input and three-phase for output: Select 1ø3W, 3ø3W, 3ø4W or 3V3A. (Applicable only to 253130)

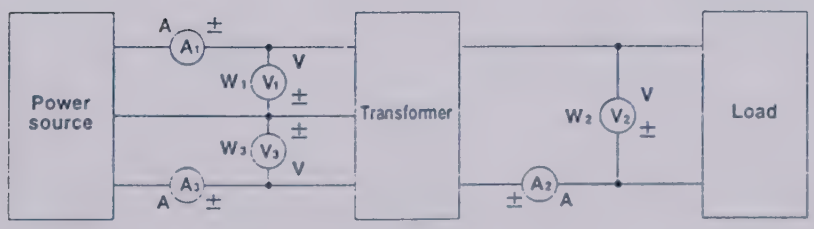


Equation: $\eta = \frac{W1 + W3}{W2} \times 100\ (\%)$

Measuring Efficiency Using the MATH Function

It is not possible to measure efficiency directly with the following wiring method. However, use of the MATH function (A + B) enables computation of efficiency. For a description of how to set the MATH function, refer to "Four Arithmetical Operations Using Display D" (page 8-4).

Display A	Display B	Equation
W2	ΣW	$\eta = \frac{W2}{\Sigma W} \times 100\ (\%)$
		$\frac{W2}{W1 + W3} \times 100\ (\%)$



Wiring system is 3ø3W.

Note

- Refer to Section "8.1 Measuring Efficiency" (page 8-1) for a description of the measurement method.
- The measured efficiency is not displayed as a percentage (%) when the MATH function is used.

4.1 Setting Measuring Conditions

Setting the Crest Factor

The crest factor for the input can be set to either "3" or "6" using the crest factor setting key.

Procedure

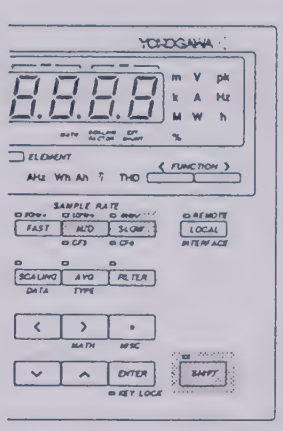
To set the crest factor to "3"

Press the CF3 key (*SHIFT* + *MID*).

To set the crest factor to "6"

Press the CF6 key (*SHIFT* + *SLOW*).

The LED for the selected crest factor will light up.



Note

- Measurement accuracy in the case of a crest factor of 6 will be 1.5 times the range error for a crest factor 3.
- The crest factor cannot be changed while integration is in progress or when it has been interrupted.

Measuring with Filter ON

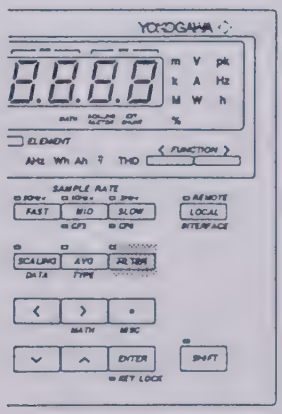
Use of a filter during measurement of switching waveforms, such as inverter waveforms, has the following advantages.

- In the case of measurement of voltage and current, similar results to those obtained in the measurement of fundamental waveforms can be obtained. Measured values are also the same as those obtained in the MEAN measurement mode.
- In the case of measurement of power, similar results to those obtained in the measurement of fundamental waveforms can also be obtained.

It is also recommended that the filter be set to ON during measurement of frequencies below 200 Hz to eliminate the effects of noise.

Turning Filter ON or OFF

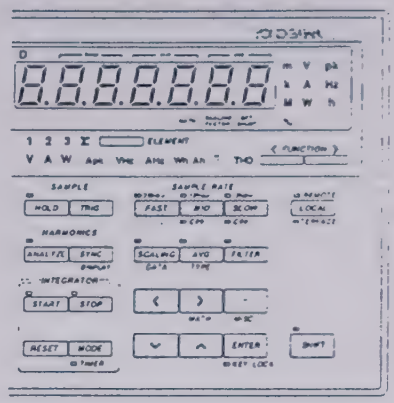
Press the *FILTER* key. The LED above the *FILTER* key is lit when the filter is ON.



Note

- Before starting measurement with the filter ON, always turn the filter OFF and make sure that the setting range is correct. Peak overflow is sometimes present in the case of pulse waveforms, therefore accurate measurement is sometimes hindered.
- The filter cannot be changed while integration is in progress or when it has been interrupted.

Setting the Sample Rate



To set the display update rate, press one of the *SAMPLE RATE* keys (*FAST*, *MID* or *SLOW* key). The LED above the key that has been pressed will light up.

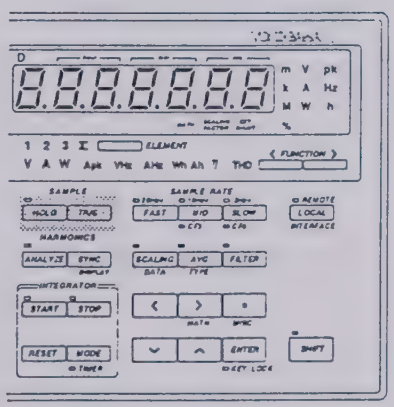
SAMPLE RATE key	Display Update Rate	Frequency Range
FAST	0.25 s	20 Hz to 200 kHz
MID	0.5 s	10 Hz to 200 kHz
SLOW	2 s	2 Hz to 200 kHz

Default setting is MID.

Note

- The display update rate is fixed at 2 s (SLOW) during integration and cannot be changed.

Display and Data Output



To hold the currently displayed measured values, press the *HOLD* key.
The LED above the *HOLD* key will light up, indicating that the hold function is currently on. Pressing the *HOLD* key again causes the LED to go out.

Updating the Data

To update the measured values, press the *TRIG* key.
The measured values are also updated when the external trigger signal is received.
If the HOLD indicator LED is lit, press the *HOLD* key.
If the measured values are output (by means of a communications channel or the D/A converter), the output values are also updated when the *TRIG* key is pressed.

Voltage and Current Measurement Modes

One of the following measurement modes can be selected for measurement of voltage and current.

RMS : Measures and displays true rms value.
MEAN : Displays rectified mean value calibrated to the rms value.
DC : Displays DC value obtained by averaging the input signal.

The theoretical equation for each measurement mode is given below.

RMS

This mode is used to display input voltage or current as a true rms value.
The default setting for measurement mode is RMS. The theoretical equation is given below.

$$\sqrt{\frac{1}{T}\int_0^T f(t)^2 dt}$$

$f(t)$: Input signal
T: One period of the input signal

MEAN

This mode is used to display input voltage or current as a rectified mean value calibrated to the rms value. Since a sine wave is used for calibration, the value displayed will be the same as that obtained in RMS mode if a sine wave is measured. However, the value displayed will be different from that obtained in RMS mode if a distorted or DC waveform is measured. The theoretical equation is given below.

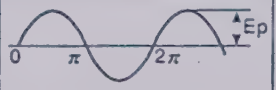
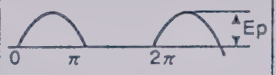
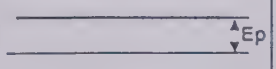
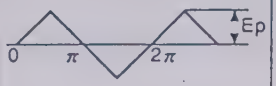
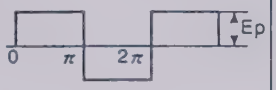
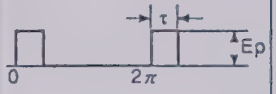
$$\frac{\pi}{2\sqrt{2}} \cdot \frac{2}{T}\int_0^{\frac{T}{2}} |f(t)|\, dt$$

$f(t)$: Input signal
T: One period of the input signal

DC

This mode is used when the input voltage or current is DC. The input signal is averaged and the result is displayed.

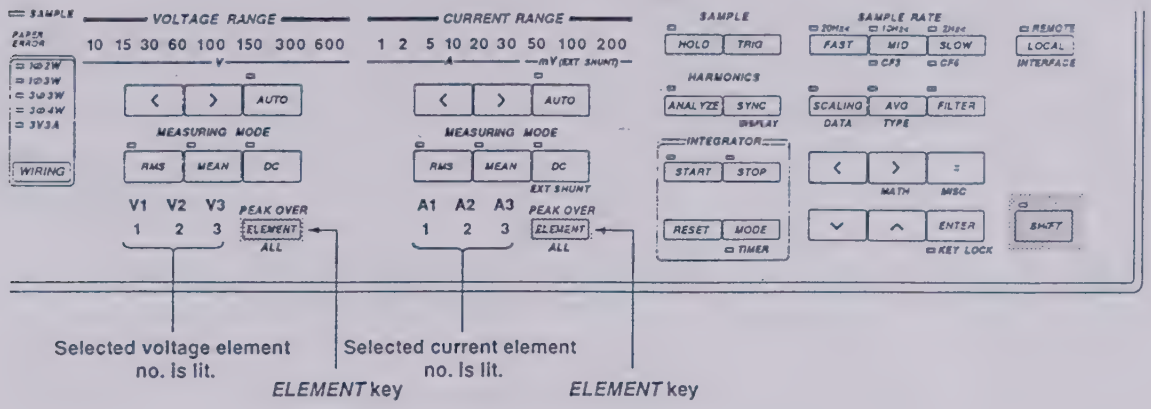
Typical Waveform Types and Differences in Measured Values Between Measurement Modes

Name	Waveform \ Measurement mode / Display	Rms value	Mean value	Mean-value rectification	Linear averaging
		RMS	—	MEAN	DC
Sine Wave		$\frac{Ep}{\sqrt{2}}$	$\frac{2}{\pi} \cdot Ep$	$\frac{Ep}{\sqrt{2}}$	0
Half-wave rectification		$\frac{Ep}{2}$	$\frac{Ep}{\pi}$	$\frac{Ep}{2\sqrt{2}}$	$\frac{Ep}{\pi}$
Full-wave rectification		$\frac{Ep}{\sqrt{2}}$	$\frac{2}{\pi} \cdot Ep$	$\frac{Ep}{\sqrt{2}}$	$\frac{2}{\pi} \cdot Ep$
Direct current		Ep	Ep	$\frac{\pi}{2\sqrt{2}} \cdot Ep$	Ep
Triangular wave		$\frac{Ep}{\sqrt{3}}$	$\frac{Ep}{2}$	$\frac{\pi}{4\sqrt{2}} \cdot Ep$	0
Square wave		Ep	Ep	$\frac{\pi}{2\sqrt{2}} \cdot Ep$	0
Pulse		$\sqrt{\frac{\tau}{2\pi}} \cdot Ep$	$\frac{\tau}{2\pi} \cdot Ep$	$\frac{\tau}{4\pi\sqrt{2}} \cdot Ep$	$\frac{\tau}{2\pi} \cdot Ep$
		When duty ratio $D (= \frac{\tau}{2\pi})$ is applied:			
		$\sqrt{D} \cdot Ep$	$D \cdot Ep$	$\frac{D}{2\sqrt{2}} \cdot Ep$	$D \cdot Ep$

4.2 Setting Measuring Ranges

Setting Voltage/Current Measuring Ranges for Each Element

Voltage and current measuring range can be set for each element.



Selected voltage element no. is lit.

ELEMENT key

Selected current element no. is lit.

ELEMENT key

Setting the Measuring Range for Each Element

1. Keep pressing the *ELEMENT* key until the desired element no. lights up.
2. Press the range setting key (<, > or *AUTO*) to set the desired measuring range.
3. Repeat steps *1* and *2* to set the desired measuring range for other elements.

Setting the Same Measuring Range for All Elements at Once

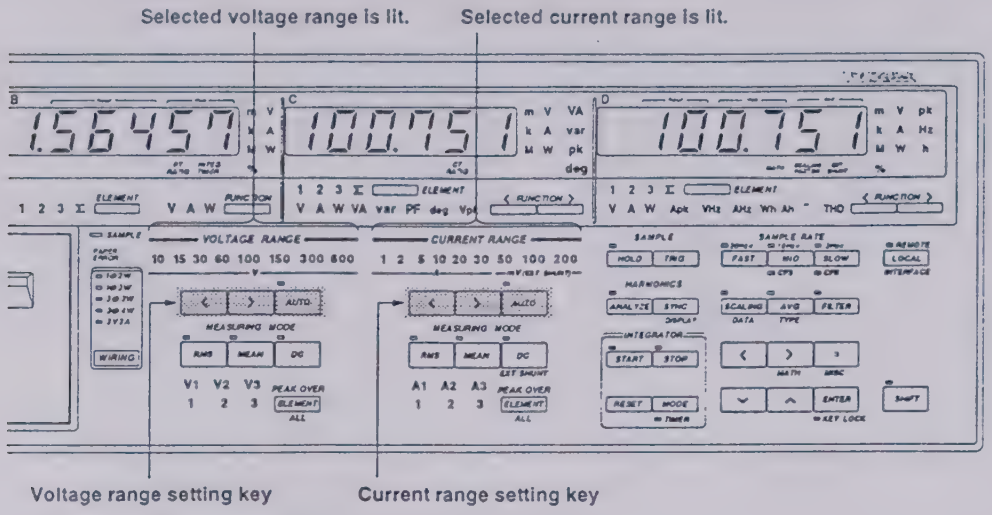
The same measuring range can be set for all elements at once using the panel key. The maximum measuring range currently set will be selected automatically for all elements.

1. Press the ALL key (*SHIFT* + *ELEMENT*).
   All element nos. will light up.

Manual and Auto Range Setting

Measuring Range Setting Method

There are two methods of setting the measuring range: auto range setting, in which the most suitable range is selected automatically, and manual range setting, in which the range is selected manually.


Selected voltage range is lit.
Selected current range is lit.
VOLTAGE RANGE
10 15 30 60 100 150 300 600
CURRENT RANGE
1 2 5 10 20 30 50 100 200
AUTO
MEASURING MODE
RMS MEAN DC
Voltage range setting key
Current range setting key

Manual Range Setting

When the AUTO indicator LED is not lit, manual range setting mode is valid. In this mode, the next lowest or highest range can be selected manually by pressing the < or > key respectively. If the AUTO indicator LED is lit, press the < or > key. This will select the next lowest (<) or highest (>) range relative to the range selected in auto range setting, and will cause the AUTO indicator LED to go out. Manual range setting mode is now valid: so press the < or > key until the desired range is selected.

Auto Range Setting

When the AUTO indicator LED is lit, auto range setting mode is valid. The measuring range is switched automatically according to the input voltage or current.

Range Up: A higher range is selected immediately if the instantaneous input voltage or current exceeds approximately 350% of the rated value during sampling (or 700% when the crest factor is 6). If the measured voltage or current exceeds 110% of the rated value, a higher range will be selected at the end of the current measurement cycle (i.e. at the next update).

Range Down: A lower range is selected if the measured voltage or current drops below 30% of the rated value.

Switching from Auto Range Setting to Manual Range Setting (when the AUTO Indicator LED is Lit)

Switching to manual range setting can be performed using one of the following procedures.

Procedure

- Press the < or > key.
  The AUTO indicator LED will go out, and manual range setting mode becomes valid. The next highest or lowest range relative to the range set in auto range setting mode will be selected.
- Press the ***AUTO*** key.
  The AUTO indicator LED will go out and manual range setting mode becomes valid.

Note

- In auto range setting mode, the range may be switched frequently if a waveform such as a pulse, which has a high crest factor, is input. In this case, set the range manually.
- Refer to Section "14 Specifications", for measurement accuracy.

Power Range

The measuring range for active power, apparent power and reactive power is determined as follows.

Wiring System	Power Range
Single-phase, two-wire (1ø2W)	Voltage range × Current range
Single-phase, three-wire (1ø3W) Three-phase, three-wire (3ø3W) Three power meter method (3V3A)	Voltage range × Current range × 2 (When the same voltage and current measuring ranges are used for all elements)
Three-phase, four-wire (3ø4W)	Voltage range × Current range × 3 (When the same voltage and current measuring ranges are used for all elements)

Display resolution is given below.

1. The maximum count is 30000 when the crest factor is 3. When the maximum is exceeded, the lowest display digit will not be used.

2. The maximum count is 10000 when the crest factor is 6. When the maximum is exceeded, the lowest display digit will not be used.

3. When the voltage range × current range exceeds 1000 W, the display unit will switch to "kW", and when it exceeds 1000 kW, the display unit will switch to "MW".

Note

- In auto range setting mode, the measuring range switches according to range up/range down conditions as described on page 4-6. Therefore, the range may vary even if the measured values remain the same.

Measuring Range for External Shunt

Scaling Function

The maximum current measuring range of this instrument is 30 A.
If the current to be measured is higher than this maximum, an external shunt can be used. Use of the scaling function enables direct reading of the measured value.

Display Item	Measured/Computed Value	Scaled Value
Current	A	Ks × A
Active power	W	Ks × W
Reactive power	var	Ks × var
Apparent power	VA	Ks × VA

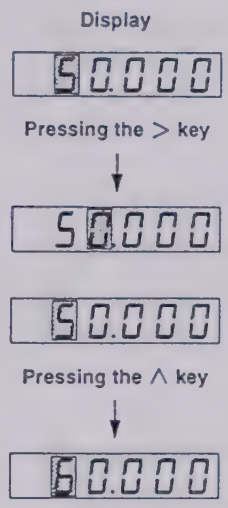
Ks: External shunt scaling value

Setting Measuring Range

1. Press the < or > key to select the measuring range (50, 100 or 200 mV).

Setting External Shunt Scaling Value

1. Press the *EXT SHUNT* key (*SHIFT* + *DC*). "SHunt" will be displayed on display A. The element currently selected is displayed on display C. Press the ∧ or ∨ key until the desired element is displayed on display C.
   The display changes in the order of ALL (all elements) → EL 1 (element 1) → EL 2 (element 2, applicable only for the 253130) → EL 3 (element 3) → End (to end making setting) and back to ALL.
   Display D displays the external shunt scaling value for the element which is currently selected for display C, with the digit on the extreme left blinking.



2. Shifting the blinking position
   The blinking position can be shifted to the left or right by pressing the < or > key respectively.
3. Setting a value
   To set the value of the blinking digit, press the ∧ or ∨ key.
   Pressing the ∧ key changes the value in the order 1, 2, 3 ... 9, 0 and back to 1.
   Pressing the ∨ key changes the value in the opposite direction.
   Default scaling value: 50.000
   Minimum scaling value: 0.0200
   Maximum scaling value: 100.00
4. Shifting the decimal point position
   The decimal point can be shifted by pressing the ▫ key.
5. After the scaling value has been set, press the *ENTER* key.
6. The next element is now displayed on display C. Repeat steps 2 to 5.
7. To exit from setting mode, select "End" on display C and then press the *ENTER* key. To exit from setting mode in the middle of making settings, press the *SHIFT* key or *DC* (*EXT SHUNT*) key.

Setting Example for External Shunt Scaling Value

When the external shunt range is 50 mV and the following shunt is used

Shunt used: 100 A/100 mV

Set the scaling value to "50.000".

When the secondary-side rating of the external shunt is not 50 mV, 100 mV or 200 mV

This problem can be solved by using the scaling function. An example is given below.

When a shunt with a rating of 50 A/60 mV is used:

(50/60 mV) × 50 mV (setting range) = 41.666...

From the above calculation, set the scaling value to "41.667".

Since the measuring range is 50 mV, make sure that the input is within the range 0 to 50 mV.

Note

- If an attempt is made to set a scaling value that is outside the setting range, error code "Err 12" is displayed. In this case, re-enter the correct value.
- To read the measured value directly when an external shunt is being used, ***SCALING*** must be set to OFF. If SCALING is ON, the measured value will be further multiplied by the CT ratio (scaling value for current) before it is displayed.
- With the 2531 with ROM version of 2.01 or above, it is possible to set shunt scaling value at once for all elements or one by one for each element, in the same way as making settings for external shunt measurement range described in this section. When making settings using communications commands, the "**CM**" command may be used to select either the use of a command used to make settings at once for all elements, or a command used to make settings one by one for each element.

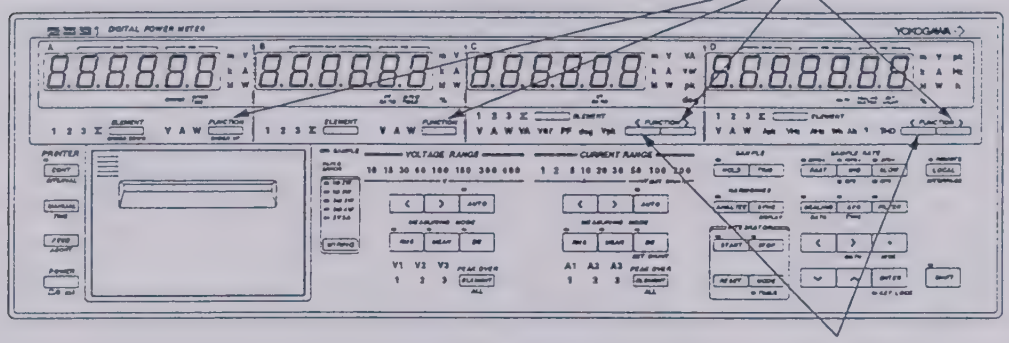
  With the 2531 with ROM version of below 2.01, only settings at once for all elements can be made. If an attempt is made to use the "**CM**" command to make settings, error 11 will occur. To ascertain the ROM version of your instrument, refer to Section "2.5 Turning the Power ON or OFF" (page 2-8). For detailed information on "**CM**" command setting, refer to the Appendix (page 1).
- If the ***ENTER*** key is pressed while "ALL" is displayed on display C, the value displayed on display D will be set to the shunt scaling value for all elements.

4.3 Selecting What to Display on Digital Displays

Selecting What to Display

The instrument has four digital displays as shown below. The information to be displayed on each display can be selected with the *FUNCTION* key and *ELEMENT* key below the display.
Each display has its own *FUNCTION* key and *ELEMENT* key.

The specific type of information to be displayed is shifted to the right each time the *FUNCTION* key is pressed.



The specific type of information to be displayed is shifted to the left each time the *FUNCTION* key is pressed.

Operating the *FUNCTION* Key

Pressing the *FUNCTION* key switches the display in the following order.
In the case of displays C and D, the sequence below shows the order in which the display information type is switched when the right-side *FUNCTION* key is pressed. Pressing the left-side *FUNCTION* key switches display information type in the opposite order.

Display A

Default setting for display A is "V" (voltage).

V (voltage) → A (current) → W (active power)

Display B

Default setting for display B is "A" (current).

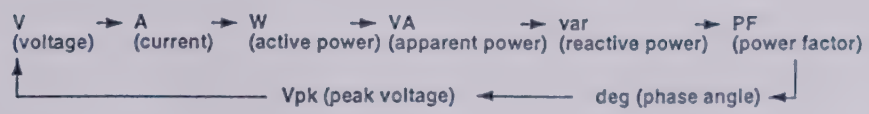
V (voltage) → A (current) → W (active power)

Note

- For display during integration, refer to Section "6.3 Displaying Integrated Value" (page 6-11).

Display C

Default setting for display C is "W" (active power).

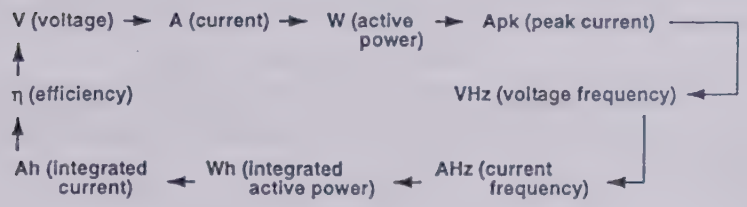


Note

- VA, var or Vpk cannot be selected during harmonic analysis.

Display D

Default setting for display D is "W" (active power).



Measurement Error

Over range

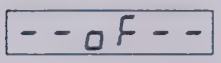
In manual range setting mode, an over range occurs if the measured voltage or current exceeds 140% of the value for the range used.

In auto range setting range, an over range error occurs if 140% of the rated value for the maximum range is exceeded.

The following code will appear on the display if an over range occurs whether the range setting mode is manual or automatic.

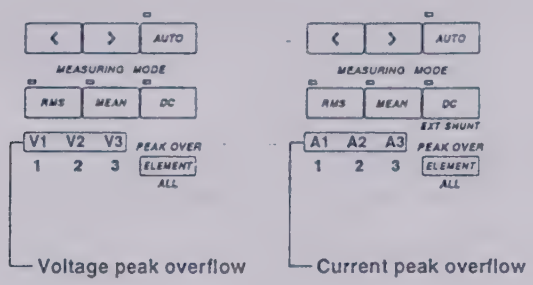
Computation overflow

If a computation overflow occurs during computation, the following code will appear on the display.



Peak overflow

If the peak value of the input voltage or current exceeds approximately 350% of the range (or 700% when the crest factor is 6), the PEAK OVER LED of the element where the peak overflow is occurring will light up.



Display condition when measured voltage or current is below 0.3% of the rated value of the range used

If the measured voltage or current is below 0.3% of the rated value, the following will appear on the display. (This applies only during RMS or MEAN mode.)

Function	Display
V (voltage) A (current) var (reactive power)	"0" is displayed.
PF (power factor)	PFErr
deg (phase angle)	dEGErr

Interruption during measurement

If the measuring range or display item is changed during measurement, the following will appear on the display.

5.1 Measuring Voltage, Current and Active Power

Setting what to Display and Element to be Measured

1. Select V (voltage measurement), A (current measurement) or W (active power measurement) by pressing the *FUNCTION* key for the display on which the measured value is to be displayed. For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-10).

2. Press the *ELEMENT* key below the same display to select the element to be measured. For details, refer to Sections "3.2 Setting Wiring System" (page 3-3) and "4.2 Setting Measuring Ranges" (page 4-5).

Setting Measuring Ranges

3. Press the voltage range or current range setting key to set the desired measuring range. For details, refer to Section "4.2 Setting Measuring Ranges" (page 4-6).

Setting Voltage/Current Measurement Mode (RMS, MEAN or DC)

4. Press the measurement mode setting key (RMS, MEAN or DC key) to set the desired measurement mode. For details, refer to Section "4.1 Setting Measuring Conditions" (page 4-3).

Power Range

- The power measuring range is determined according to the selected voltage and current ranges. For details, refer to Section "4.2 Setting Measuring Ranges" (page 4-7).
- For power measuring range, refer to Section "14 Specifications."

5.2 Measuring Peak Voltage and Current

Measured peak voltage is displayed on display C, whilst measured peak current is displayed on display D.

Setting Element to be Measured

1. Select Vpk (peak voltage) by pressing the *FUNCTION* key below display C, and select Apk (peak current) by pressing the *FUNCTION* key below display D. For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11).

2. Press the *ELEMENT* key below the same display to select the element to be measured. For details, refer to Sections "3.2 Setting Wiring System" (page 3-3) and "4.2 Setting Measuring Ranges" (page 4-5).

Setting Measuring Ranges

3. Press the voltage range or current range setting key to set the desired measuring range. For details, refer to Section "4.2 Setting Measuring Ranges" (page 4-6).

Setting Voltage/Current Measurement Mode (RMS, MEAN or DC)

Measured peak voltage or current is independent of the measurement mode.

5.3 Displaying Computed Apparent Power

Basic Computing Equation

For details, refer to Section "14 Specifications."

Computing Accuracy

For details, refer to Section "14 Specifications."

Computing Range for Apparent Power

For details, refer to Section "14 Specifications."

Rated Value for Apparent Power

Voltage and current ranges are combined to measure apparent power.
For details, refer to Section "4.2 Setting Measuring Ranges" (page 4-7).

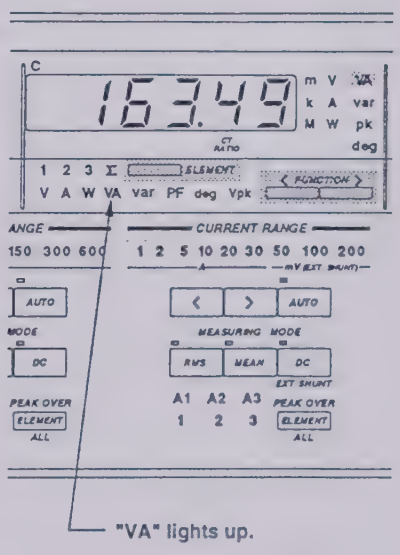
Function Setting

Operating the *FUNCTION* Key

Computed apparent power is displayed on display C.

Press the *FUNCTION* key below display C to select VA (apparent power).

For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11).



Setting Element to be Measured

Operating the *ELEMENT* Key

Press the *ELEMENT* key below display C to select the element to be measured.

Setting *WIRING* System

For details, refer to Section "3.2 Setting Wiring System" (page 3-3).

Note

- Even if the measurement mode for voltage is different from that for current, computation is still carried out with the modes unchanged.
  For instance, if the voltage measurement mode is Vrms and the current measurement mode is Amean, the computed apparent power will be the result of Vrms × Amean.

5.4 Displaying Computed Reactive Power

Basic Computing Equation

For details, refer to Section "14 Specifications."

Computing Accuracy

For details, refer to Section "14 Specifications."

Computing Range for Reactive Power

For details, refer to Section "14 Specifications."

Rated Value for Reactive Power

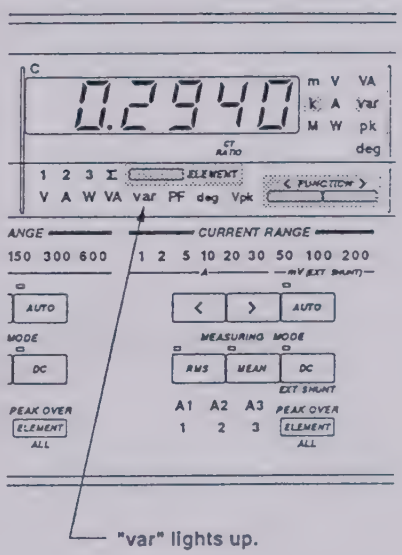
Voltage and current ranges are combined to measure reactive power.
For details, refer to Section "4.2 Setting Measuring Ranges" (page 4-7).

Function Setting

Operating the *FUNCTION* Key

Press the *FUNCTION* key below display C to select var (reactive power).

For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11).



Setting Element to be Measured

Operating the *ELEMENT* Key

Press the *ELEMENT* key below display C to select the element to be measured.

Setting WIRING System

For details, refer to Section "3.2 Setting Wiring System" (page 3-3).

Note

- Even if the measurement mode for voltage is different from that for current, computation is still carried out with the modes unchanged. For instance, if the voltage measurement mode is Vrms and the current measurement mode is Amean, the apparent power will be obtained using the equation "var = $\sqrt{(\text{Vrms} \times \text{Amean})^2 - W^2}$ ".

5.5 Displaying Computed Power Factor

Basic Computing Equation

For details, refer to Section "14 Specifications."

Computing Accuracy

For details, refer to Section "14 Specifications."

Display Range

Display range: −1.0000 to 1.0000

If the computation result exceeds "1" due to inputs being outside the effective operating input range, the following will be displayed.

Computation Result	Display
1.0001 to 2.0000	10000
2.0001 or higher	PFErr

If either input voltage or input current is below 0.3% of the rated value of the range used, "PFErr" will be displayed.

Function Setting

Operating the *FUNCTION* Key

Press the *FUNCTION* key below display C to select PF (power factor).

For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11).

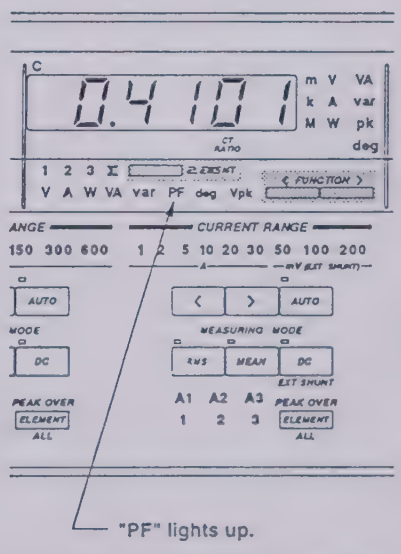
Setting Element to be Measured

Operating the *ELEMENT* Key

Press the *ELEMENT* key below display C to select the element to be measured.

Setting *WIRING* System

For details, refer to Section "3.2 Setting Wiring System" (page 3-3).



Note

- Even if the measurement mode for voltage is different from that for current, computation is still carried out with the modes unchanged. For instance, the voltage measurement mode is Vrms and the current measurement mode is Amean, the power factor will be obtained using the equation "$PF = \frac{W}{Vrms \times Amean}$."

5.6 Displaying Computed Phase Angle

Basic Computing Equation

For details, refer to Section "14 Specifications."

Computing Accuracy

For details, refer to Section "14 Specifications."

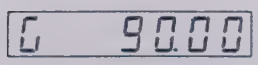
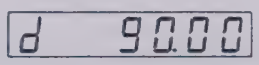
Computing Range for Phase Angle

For details, refer to Section "14 Specifications."

Display Resolution

For details, refer to Section "14 Specifications."

Distinction between phase lag and lead is indicated as below.

Phase Lag	Phase Lead
	

If the power factor exceeds "1", the following will be displayed.

Power Factor	Display
1.0001 to 2.0000	0.00 deg
2.0001 or higher	dEGErr

Note

- Before computing the phase angle (deg), make sure that both the voltage and current are within the effective measurement range.
- Distinction between phase lag and lead is made properly only when both voltage and current are sine waves.
- If either the measured voltage or current is below 0.3% of the rated value of the range used, "dEGErr" will be displayed.
- Even if the measurement mode for voltage is different from that for current, computation is still carried out with the modes unchanged. For instance, if the voltage measurement mode is Vrms and the current measurement mode is Amean, the phase angle (deg) will be obtained using the equation

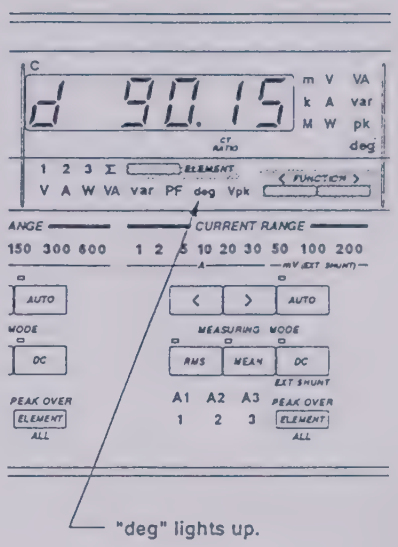
"deg = $\cos^{-1}\left(\frac{W}{Vrms \times Amean}\right)$".

Function Setting

Operating the *FUNCTION* Key

Press the *FUNCTION* key below display C to select deg (phase angle).

For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11).



Setting Element to be Measured

Operating the *ELEMENT* Key

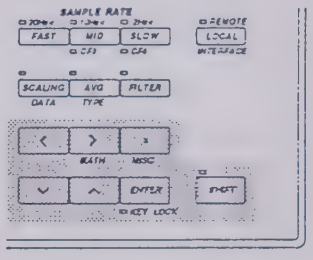
Press the *ELEMENT* key below display C to select the element to be measured.

Setting *WIRING* System

For details, refer to Section "3.2 Setting Wiring System" (page 3-3).

Setting Phase Angle Display Method

1. Press the *MISC* key (*SHIFT* + ▫.)
   Press the ∧ or ∨ key until "dEG" appears on display D.



2. Press the *ENTER* key.
   "dEG" will disappear from display D, and instead will appear on display A. The phase angle display method currently set will appear on display B.
   Default setting: 180°

Display B

3. Press the ∧ or ∨ key to set the phase angle display method. (180° or 360°)

4. Press the *ENTER* key.

Note

- The phase angle is displayed as follows when the 360° display method is selected.

  Calculation is performed using $\cos^{-1}\left(\frac{W}{VA}\right)$, which gives a phase angle between 0° and 180°. Distinction of phase lag/lead is then made, and computed results are displayed.

  In the case of phase lag: phase angle calculated using $\cos^{-1}\left(\frac{W}{VA}\right)$ is displayed.

  In the case of phase lead: phase angle calculated using $360° - \cos^{-1}\left(\frac{W}{VA}\right)$ is displayed.

  No phase lag or lead code (L or d) is indicated.

6.1 Overview of Integrator Functions

Integration Modes

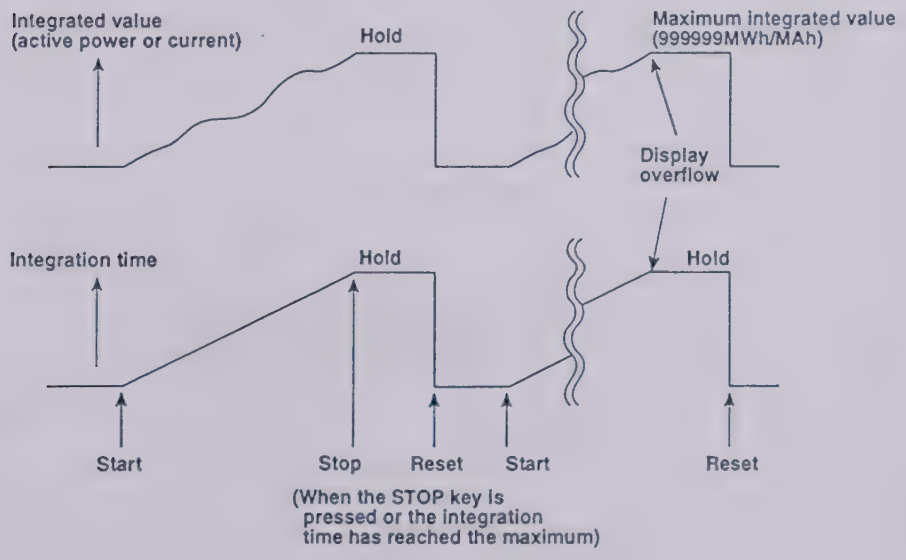
The following displays and 4 integration modes can be selected by setting the function of display D to Wh (active power integration) or Ah (current integration).

Display A	Display B	Display C	Display D
Display of elapsed time of integration	Display of active power	Display of active power (Displayed only when the function of display D is set to Wh)	Display of integrated value

Integration Mode	Start	Stop	Repeat	Integration Time
1. Manual integration	*START* key Through communications cable or external input	*STOP* key	No	From start to stop
2. Standard integration	*START* key	Integration timer	No	Time set on integration timer
3. Continuous integration	*START* key	*STOP* key	Yes	Time set on integration timer
4. Real time counting				
Standard integration	Reserved start time	Reserved stop time	No	Reserved time duration
Continuous integration	Reserved start time	Reserved stop time	Yes	Time set on integration timer

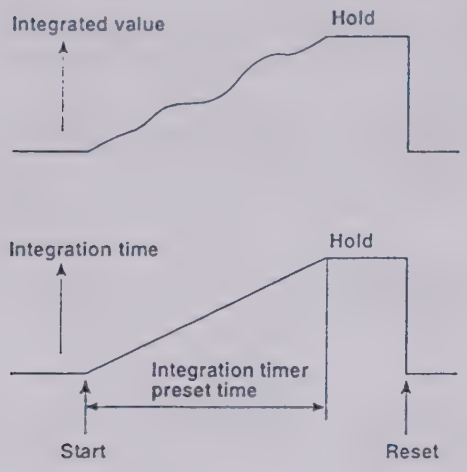
Manual Integration Mode

In this mode, integration starts when the *START* key is pressed (or when a start signal is received via a communications cable), and stops when the integration time reaches the maximum (999 hours and 59 minutes) or the integrated power (Wh) or current (Ah) reaches the maximum (999999 MWh/MAh). The instrument holds the integration time and power (or current) of the stop point.



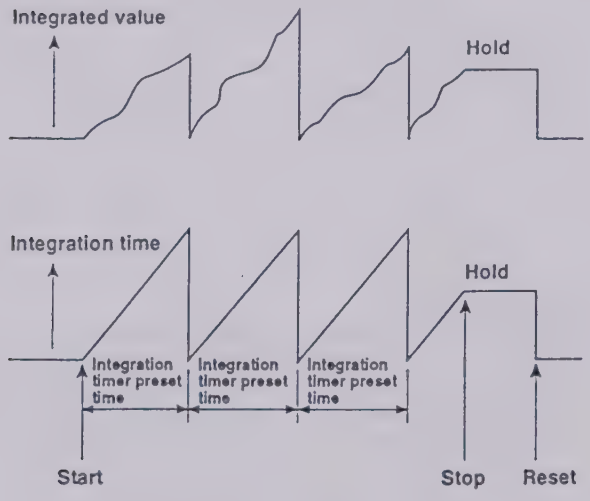
Standard Integration Mode (Timer Mode)

In this mode, integration starts when the ***START*** key is pressed, and stops when the timer preset time is reached or the integrated value reaches the maximum, whichever is first. The instrument holds the integration value and integration time of the stop point.



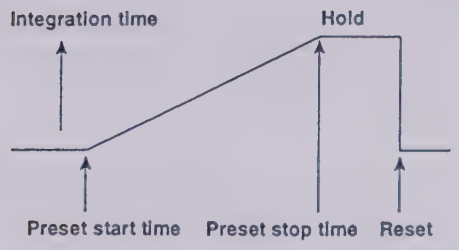
Continuous Integration Mode (Repeat Integration)

In this mode, integration starts when the ***START*** key is pressed. When the timer preset time is reached, the integrated value and integration time are reset automatically and restarted immediately. This is repeated continuously until the ***STOP*** key is pressed. If the integrated value reaches the maximum before the timer preset time is reached, integration stops and the instrument holds the integration value and integration time.



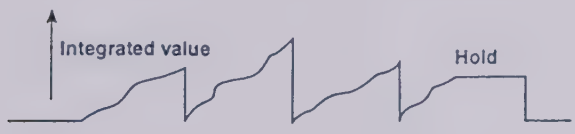
Real Time Counting Standard Integration Mode

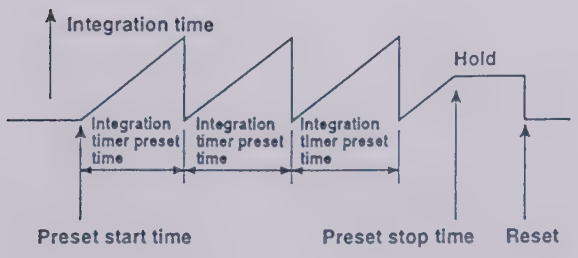
In this mode, integration start/stop time can be set to an actual time. Integration starts at the preset start time, and it stops when the preset stop time is reached or the integrated value reaches the maximum. The instrument holds the integrated value and integration time of the stop point.



Real Time Counting Continuous Integration Mode (Repeat Integration)

In this mode, integration start/stop time can be set to an actual time. Integration starts at the preset start time, and is repeated at intervals (timer preset time) until the preset stop time is reached. When the timer preset time is reached, the integrated value and integration time are reset automatically and restarted immediately. When the preset stop time is reached or the integrated value reaches the maximum, integration stops and the instrument holds the integrated value and integration time.





Starting, Stopping and Resetting Integration

There are three ways to start, stop and reset integration. For details, refer to the pages given below.

- Using the *START* and *STOP* keys (Integrator): refer to Section "6.3 Displaying Integrated Value" (6-10.)
- Using GP-IB/RS-232-C commands: refer to Sections "11.1 Using the GP-IB Interface" (page 11-9) and "11.2 Using the RS-232-C Interface" (page 11-16).
- Using an external signal: refer to Section "10.2 Remote Control" (page 10-2.)

Display Update Rate

Display update rate is set to *SLOW* (2 s) automatically when integration is started. If the *SAMPLE RATE* key is pressed in an attempt to change the display update rate, an error code "Err 13" will be displayed.

Sampling Frequency and Measuring Frequency Range

A sampling frequency of approximately 135 kHz is used for integration. All sample data is integrated at this frequency.

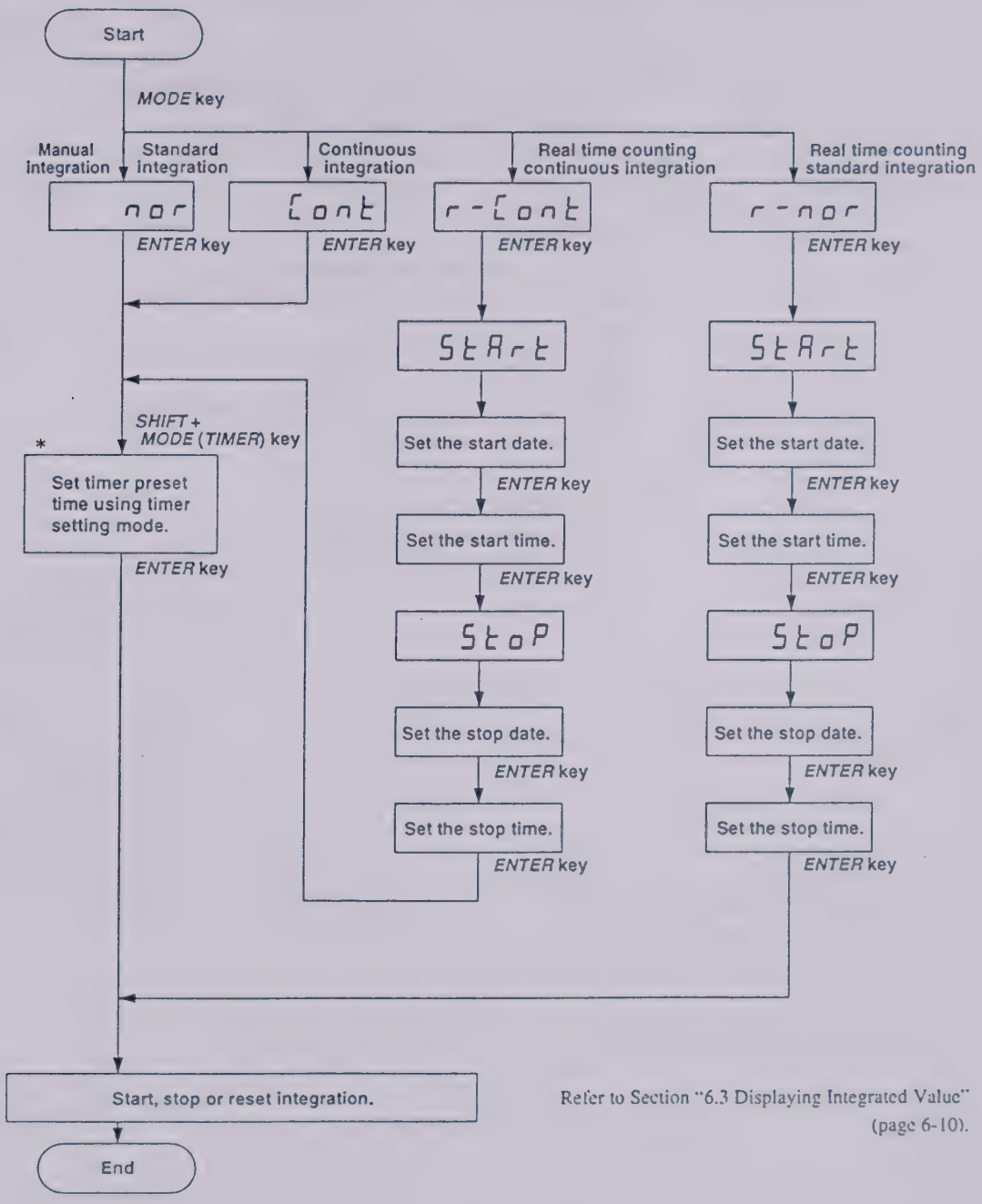
		Measuring Frequency Range
Power integration		DC to 50 kHz
Current integration (Measurement mode)	RMS/MEAN	DC, 20 Hz to 50 kHz
	DC	DC to 50 kHz

Computing equations are given below.

Power integration		$\sum_{N=0}^{n} (\sum v_i \cdot i_i) \equiv \sum_{N=0}^{n} v_i \cdot i_i$
Current integration	RMS	$\sum_{N=0}^{n} (\sqrt{\sum i_i^2})$
	MEAN	$\sum_{N=0}^{n} (\sum \lvert i_i \rvert) \equiv \sum_{N=0}^{n} \lvert i_i \rvert$
	DC	$\sum_{N=0}^{n} (\sum i_i) \equiv \sum_{N=0}^{n} i_i$

( ): Integrated value at each display update interval
N: No. of updates
V_i, i_i: Sample data

Flow of Operations



Refer to Section "6.3 Displaying Integrated Value" (page 6-10).

* If you are using manual integration mode, set the timer preset time to "000" hour and "00" minute.

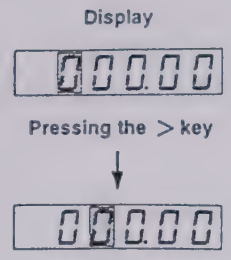
Common Operations for All Integration Modes (Setting the Date, Time and Integration Timer)

Shifting the Blinking Position

The blinking position can be shifted to the left or right by pressing the < or > key.

Pressing the < key causes the digit to the left of the currently blinking digit to blink, and pressing the > key causes the digit to the right of the currently blinking digit to blink.

The blinking position wraps around in both directions.



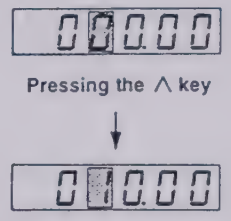
Setting a Value

To set a value of the blinking digit, press the ∧ or ∨ key.

Pressing the ∧ key changes the value in the order 1, 2, 3 ... 9, 0 and back to 1.

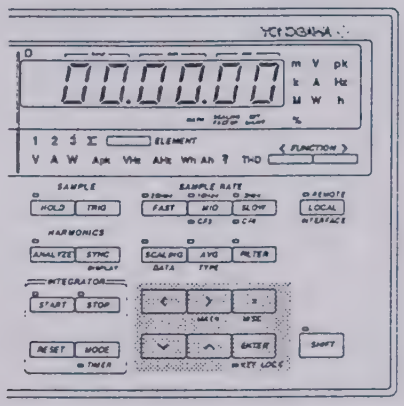
However, in the time setting, the value of the second lowest digit changes in the order 1, 2, 3, 4, 5, 0 and 1.

Pressing the ∨ key changes the value in the opposite direction.



Confirming Entry

After setting the date (or time or integration timer), press the *ENTER* key.



Display Resolution during Integration

The display resolution for integrated values is 300000 counts. The decimal point shifts automatically according to the elapsed time of integration, constantly maintaining high measurement accuracy.

The decimal point shifting timing is determined automatically according to the selected voltage and current measuring ranges. After the rated value is set for both voltage and current measuring ranges, the decimal point shifts when the integrated value exceeds 300000 counts. However, the minimum measurement unit is 1/1000 times the power range which is determined by the rated voltage and current ranges, and the maximum measurement unit is "MWh".
For instance, the elapsed time of integration and integrated value are displayed as follows when the voltage and current measuring ranges are 100 V and 5 A respectively.

Elapsed Time			Integrated Value	
H	M	S		
		0	0.00000	mWh
		2	277.778	mWh
		3	416.67	mWh
		⋮		
		7	972.22	mWh
		8	1.11111	Wh
		⋮		
		21	2.91667	Wh
		22	3.0556	Wh
		⋮		
	3	36	30.0000	Wh
	3	37	30.139	Wh
		⋮		
1	0	0	500.00	Wh
		⋮		
2	0	0	1.00000	MWh
		⋮		
6	0	0	3.00000	MWh
		⋮		
10	0	0	5.0000	MWh

Current Integration

- As explained earlier, there are three measurement modes for measurement of current; RMS, MEAN and DC. Likewise, there are three types of current integration, corresponding to the three types of measurement. (Refer to Section "6.1 Overview of Integrator Functions" (page 6-4).) When the measuring mode is DC, the polarity is also displayed. This feature is convenient for measuring battery charging/discharging.
- If the current measuring range is RMS or MEAN and the input current is below 0.3% of the rated value of the range, integration will be carried out with the input current considered to be "0".

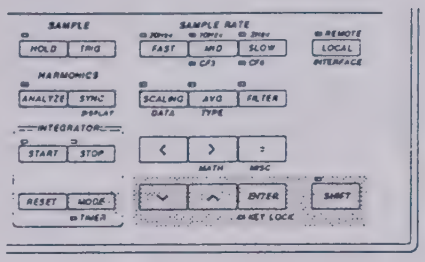
6.2 Setting Integration Modes

Setting Integration Mode and Integration Timer

Setting the Mode

1. Press the *MODE* key.

   The mode currently set will be displayed on display A. Select the desired integration mode by pressing the ∧ or ∨ key. Pressing the ∧ key changes the mode in the following order, and pressing the ∨ key changes it in the opposite direction.



Display A	Description
nor (default)	Manual or standard integration mode
Cont	Continuous integration mode
r-nor	Real time counting standard integration mode
r-Cont	Real time counting continuous integration mode

2. Press the *ENTER* key.

   When the desired mode is displayed on display A, press the *ENTER* key.

   A display example for each display is shown below.

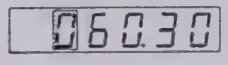
Display A	Display B	Display C	Display D
nor (Manual or standard integration mode)	None	None	None
Cont (Continuous integration mode)	None	None	None
r-nor (Real time counting standard integration mode)	StArt StoP	93/12/05 93/12/05	00:00:00 00:00:00
r-Cont (Real time counting continuous integration mode)	StArt StoP	93/12/05 93/12/05	00:00:00 00:00:00

Setting the Timer Preset Time

3. Press the *TIMER* key (*SHIFT* + *MODE*).

   The timer setting mode is now in operation. The time currently set will be displayed on display B, with the leftmost digit blinking.

Display B



H M

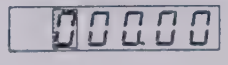
4. Set the desired time as follows.

   Press the < or > key until the digit for which you wish to set a value is blinking, then press the ∧ or ∨ key to set the desired value. Refer to Section "6.1 Overview of Integrator Functions" (page 6-6).

   (When using manual integration mode, set the time to "(XX):(X)".)

   Maximum time allowed: 999 (hours) 59 (minutes)

Display B



H M

5. When the desired time has been set, press the *ENTER* key.

   The TIMER indicator LED located below the *MODE* key will be lit, indicating that the time has been confirmed.

Integration Using Real Time Counting Standard Integration Mode or Real Time Counting Continuous Integration Mode

When real time counting standard mode is used, the timer preset time is invalid.
When real time counting continuos mode is used, an error occurs if integration is started with the timer preset time set to "000.00".

Setting the Start and Stop Date and Time

Setting the Start Date

1. "StArt" is displayed on display B and the start date currently set is displayed on display C. Use the ∧, ∨, < and > keys to set the desired start date. Refer to Section "6.1 Overview of Integrator Functions" (page 6-6).

Display C

Y M D

2. Press the ***ENTER*** key.

Setting the Start Time

3. The start time currently set is displayed on display C. Use the ∧, ∨, < and > keys to set the desired start time.

Display D

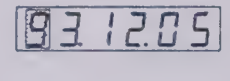
H M S

4. Press the ***ENTER*** key.
"StoP" is now displayed on display B.

Setting the Stop Date

5. The stop date currently set is displayed on display C. Use the ∧, ∨, < and > keys to set the desired stop date.

Display C



6. Press the ***ENTER*** key.

Setting the Stop Time

7. The stop time currently set is displayed on display C. Use the ∧, ∨, < and > keys to set the desired stop time.

Display D

8. Press the ***ENTER*** key.

Note

- If the stop date or time is before the start date or time, an error code "Err 12" will be displayed. It is not possible to set a stop date or time that is before the start date or time.
- Years whose final two digits are less than "93" will be treated as 21st century years.

00	→	2000
⋮		⋮
92	→	2092
93	→	1993
⋮		⋮
99	→	1999

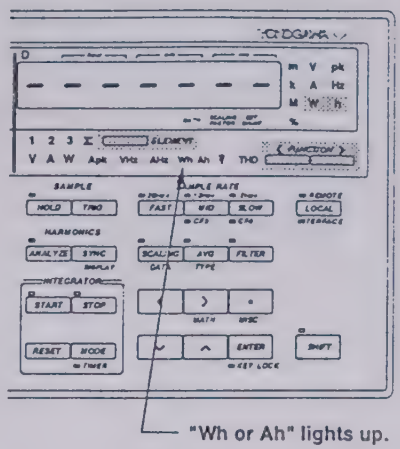
6.3 Displaying Integrated Value

Function Setting

Operating the *FUNCTION* Key

Press the ***FUNCTION*** key below display D to select Wh or Ah.

For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11.)



Setting Element to be Measured

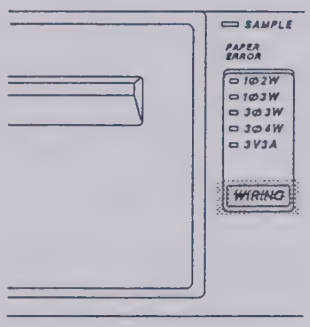
Operating the ***ELEMENT*** Key

Press the ***ELEMENT*** key below display D to select the element to be measured.

For details, refer to Section "3.2 Setting Wiring System" (page 3-3.)

Setting *WIRING* System

For details, refer to Section "3.2 Setting Wiring System" (page 3-3).

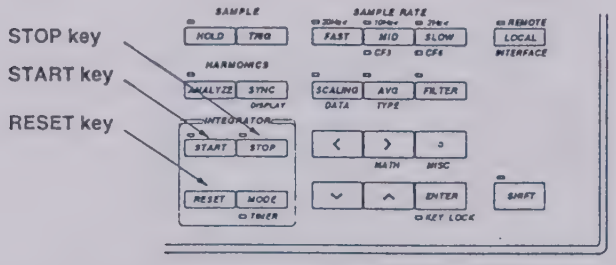


Setting the Display Update Rate

Display update rate is fixed to SLOW (2 s) automatically.

Starting, Stopping and Resetting Integration

The elapsed time of integration is displayed on display A, and the integrated value is displayed on display D.



Starting Integration

Press the ***START*** key.

Integration will start. Make sure that the START indicator LED is lit.

In real time counting standard or continuous mode, the START indicator LED blinks, indicating that the instrument is in standby state. (Integration will start automatically when the start date and time is reached.)

If the stop date and time has already passed, an error code "Err48" will be displayed when the ***START*** key is pressed.

Stopping Integration

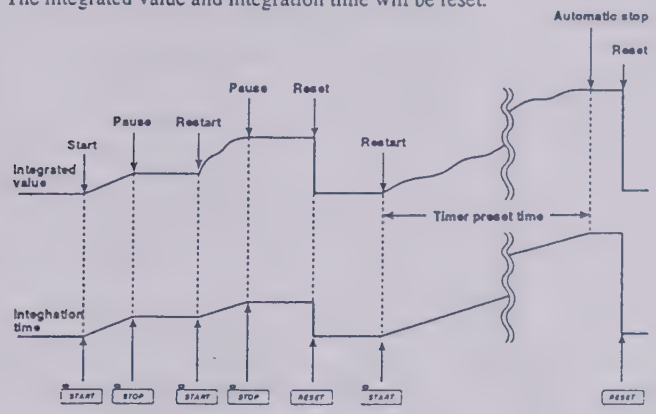
Press the *STOP* key.

- If the *STOP* key is pressed while integration is in progress, integration will be paused. The instrument holds the integration time and integrated value of the stop point until the *START* key is pressed again.
- The STOP indicator LED lights up when the *STOP* key is pressed.
- When the integrated power reaches the maximum, integration will stop and the instrument holds the integrated value and integration time.

Resetting Integration

Press the *RESET* key after integration has been stopped.

- The integrated value and integration time will be reset.



Integration Overflow Display

If the integrated value reaches the maximum (±999999 MWh), integration will stop and the instrument will hold that value.

Holding the Integrated Value

Pressing the *HOLD* key during integration will light up the HOLD indicator LED and hold the integrated value of the time at which the HOLD key is pressed. To update the displayed value, press the *TRIG* key.

For details, refer to Section "6.4 Precautions Regarding Use of Integrator Function" (page 6-12.)

Display Content and Range

Display A	Display B	Display C	Display D
Elapsed time of integration	Active power	Active power	Integrated value Maximum ±999999 MWh or ±999999 MAh

Note

- Displays B and C are valid only when their function is set to "W" (active power). Otherwise, "- - - - - -" will be displayed.
- "- - - - - -" will be displayed on displays B and C for the first measurement after the *START* key is pressed.
- The previous measured value (not the latest measured value) will be displayed just after the *STOP* key is pressed.

Displaying the Polarity of the Integrated Value

Integrated active power sometimes decrease in the case of battery discharge. If the integrated power is negative, "–" will be displayed in front of the integrated value.

6.4 Precautions Regarding Use of Integrator Function

Integration When Display Hold is ON

When the *HOLD* key has been pressed to activate the display update hold function, i.e. when the HOLD indicator LED is lit, integrated values displayed and output through a communications interface are on hold, but integration is still carried out whether the display update hold function is ON or OFF. The SAMPLE indicator LED continues to blink.

- As shown in Fig. (a), if integration is started while the display update hold function is ON, the displayed integrated value remains unchanged. However, as soon as the display update hold function is turned OFF or the *TRIG* key is pressed, the integrated value accumulated up to that moment will be displayed.
- As shown in Fig. (b), if integration is stopped while the display update hold function is ON, the displayed integrated value remains unchanged. However, as soon as the display update hold function is turned OFF or the *TRIG* key is pressed, the integrated value obtained when the STOP key was pressed will be displayed.

Fig (a)

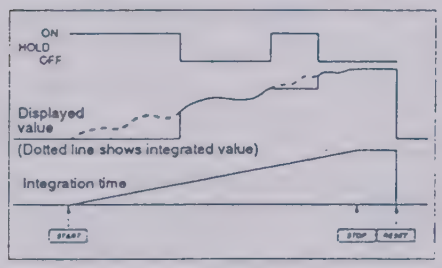
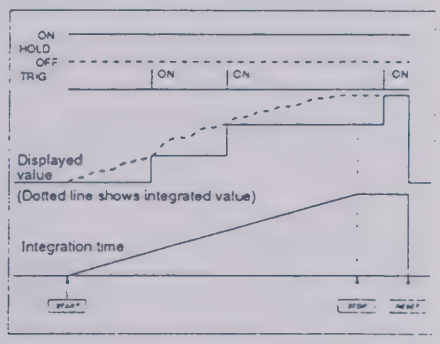


Fig. (b)



Backup During Power Failures

If there is a power failure while integration is in progress, the integrated value and integration time will be backed up.

- In this case, integration will remain stopped even if power is restored or the *START* key is pressed. To restart integration, first press the *RESET* key to cancel integration, then press the *START* key.
- When power is restored after a power failure, the integrated value and elapsed time of integration up to the time of the power failure will be displayed.

Panel Key Operation During Integration Mode

During integration mode, certain key operations are restricted so that settings are not accidentally changed when operating keys are pressed. The table below show these restrictions.

Operation key		Integration state: Integration stopped (START LED) Not lit (STOP LED) Not lit	Integration in progress Lit Not lit	Integration paused Not lit Lit
MODE	*RMS,MEAN,DC*	○	×	×
	AVG	○	×	×
	SCALING	○	○	○
SAMPLE	*HOLD*	○	○	○
	TRIG (display update hold ON)	○	○	○
RANGE	*VOLTAGE AUTO* <,>	○	×	×
	CURRENT AUTO <,>	○	×	×
CF		○	×	×
FILTER		○	×	×
Data setting	*SCALING (DATA)* *MODE (TIMER)* ∧,∨,<,> *ENTER*	○	○ In the case of the *TIMER* key, key operation is not possible, but the timer preset time can be displayed.	○ In the case of the *TIMER* key, key operation is not possible, but the timer preset time can be displayed.
FUNCTION (Display A)		×	×	×
FUNCTION (Displays B, C, D)		○	○	○
Wiring system	*WIRING*	○	○	○
INTEGRATOR	*START*	○	×	○
	STOP	×	○	×
	RESET	○	×	○

× : Key operation is not possible.
○ : Key operation is possible.

- Error code "Err 13", "Err42", "Err44" or "Err45" will appear on display D if any key that cannot be operated is pressed.
- It is not possible to reset the integrated value while integration is in progress. To reset the integrated value, press the *STOP* key to interrupt integration, then press the *RESET* key.
- To use keys whose operation is invalidated while integration is in progress, press the *STOP* key to interrupt integration, then press the *RESET* key to reset the displayed integrated value.
- If integration is started while auto range setting mode is active, the range setting mode will be switched to manual range setting mode, but the measuring range will remain unchanged.

Integrated Value when Instantaneous Measured Value Exceeds Measurement Limits

If the instantaneous measured value exceeds the measurement limits, computation is carried out as follows. In this case, it is not possible to obtain correct integrated values.

- If the instantaneous input exceeds 3.5 times the rated value of the measuring range when the crest factor is "3", the measured value is considered to be 3.5 times the rated value of the measuring range when computing the integrated value.
- If the instantaneous input exceeds 7 times the rated value of the measuring range when the crest factor is "6", the measured value is considered to be 7 times the rated value of the measuring range when computing the integrated value.

7.1 Measuring Frequency

Display Range

For display range, refer to Section "14 Specifications."

If the input signal level is low or the input frequency is below the measurement range, the error code "Err-Lo" will be displayed. The same error code will also be displayed if no input signal is input to the input element.

If the input frequency is above the measurement range, error code "Err-Hi" will be displayed.

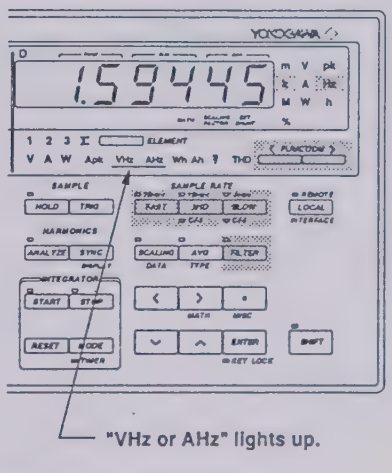
Displaying Measured Frequency

The measured value is displayed on display D.

Operating the *FUNCTION* Key

Press the ***FUNCTION*** key below display D to select VHz (voltage frequency) or AHz (current frequency).

For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11).



Setting the Sample Rate

Press one of the ***SAMPLE RATE*** keys (FAST, MID or SLOW). The minimum displayed value is decided according to the sample rate as shown below.

SAMPLE RATE setting Key	Minimum Display	Measurement Time
FAST key (20 Hz≦)	18.00 Hz	60 ms
MID key (10 Hz≦)	9.000 Hz	120 ms
SLOW key (2 Hz≦)	1.8000 Hz	600 ms

Measuring Frequency with Filter ON

The filter can be used to eliminate noise or harmonics, such as those that appear in invertor waveforms, when measuring the fundamental frequency. To eliminate noise during measurement of frequencies below 200 Hz, it is also recommended that you turn ON the filter and set the sample rate to SLOW. For details, refer to Section "4.1 Setting Measuring Conditions" (page 4-1).

Note

- If the filter is ON and a signal with a frequency of 500 Hz or higher is input, an error code "Err-Lo" may be displayed depending on the frequency and level of the signal. This is because the signal is attenuated by the filter and therefore its presence is not recognized.

8.1 Measuring Efficiency

Display Resolution

The display resolution for efficiency measurement is 0.01.

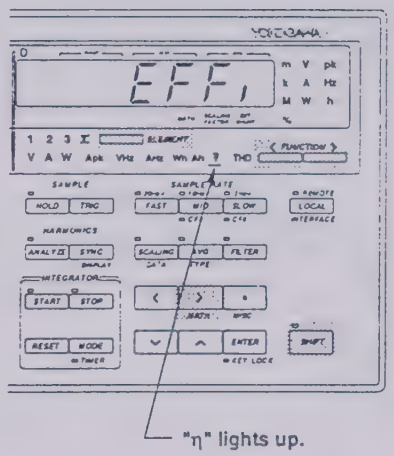
Displaying the Computed Value

The computed result is displayed on display D as a percentage (%).

Function Setting

Operating the *FUNCTION* Key

1. Press the *FUNCTION* key below display D to select "η" (efficiency).
   For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11.)



2. Press the *MATH* key (*SHIFT* + >).
   "EFF1" will be displayed on display D. If "EFF1" is not displayed, press the ∧ or ∨ key until it is displayed. The symbol displayed on display D changes in the following order.

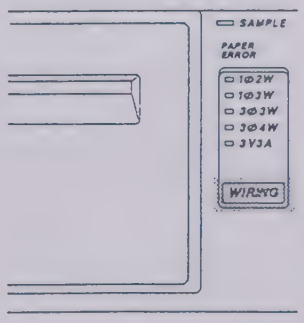
EFF1 → [F U1 → ([F U2) → [F U3 → [F A1 → ([F A2) → [F A3 → A + b → A - b → A ×1 b → A ÷ b → EFF1 ---

Symbols within brackets are displayed only on the three-phase, four-wire model (253130).

3. Press the *ENTER* key.

Setting Wiring System

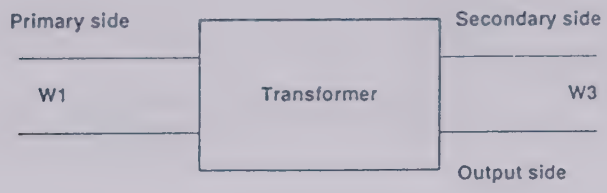
4. Set the wiring system by pressing the *WIRING* key.
   Computing equations for efficiency are given on the next page. Make sure that the correct wiring system is selected, otherwise incorrect computed values will be obtained.



Wiring Systems and Basic Computing Equations

When both the input and output wiring systems are two-wire system

Select 1ø2W, 1ø3W (for 253120) or 3ø3W (for 253120).



Computing equation

$$\text{Efficiency } (\eta) = \frac{W3}{W1} \times 100$$

When the input is two-wire and the output is a three-wire system

Select 1ø3W, 3ø3W, 3ø4W or 3V3A. This is only applicable for the 253130.

Computing equation

$$\text{Efficiency } (\eta) = \frac{W1 + W3}{W2} \times 100$$

Note

- For the basic computing equations and the wiring method, refer to Section "3.5 Wiring System and Equations of Efficiency" (page 3-15).

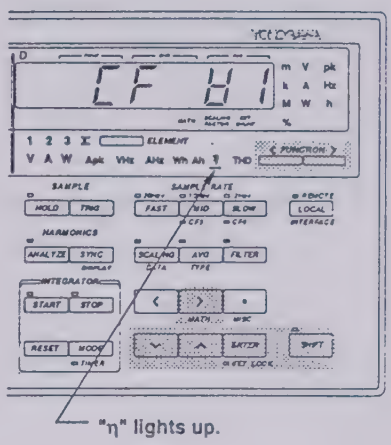
8.2 Measuring the Crest Factor

When "η" (efficiency) is selected for display D, the MATH function calculates the crest factor and displays it on display D.

Function Setting

Operating the *FUNCTION* Key

1. Press the ***FUNCTION*** key below display D to select "η" (efficiency).
   For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11.)



Setting the Computing Equation

2. Press the ***MATH*** key (***SHIFT*** + >).
3. Press the ∧ or ∨ key. The computing equation displayed on display D changes in the following order. Select one of the computing equations from CF U1 to CF U3 and CF A1 to CF A3.

EFF, → CF U1 → (CF U2) → CF U3 → CF A1 → (CF A2) → CF A3 → A + b → A − b → A ×, b → A ÷ b → EFF, ---

Symbols within brackets are displayed only on the three-phase, four-wire model (253130).

4. Press the ***ENTER*** key.

Crest Factor Computing Equations and Display

- CF U1 : (Peak value of V1) ÷ (rms value of V1)
- CF U2 : (Peak value of V2) ÷ (rms value of V2) (Available only for 253130)
- CF U3 : (Peak value of V3) ÷ (rms value of V3)
- CF A1 : (Peak value of A1) ÷ (rms value of A1)
- CF A2 : (Peak value of A2) ÷ (rms value of A2) (Available only for 253130)
- CF A3 : (Peak value of A3) ÷ (rms value of A3)

Note

- Crest factor is defined as $\frac{\text{peak value}}{\text{rms value}}$.
- "- - - - - -" will be displayed if the measuring mode is MEAN or DC.

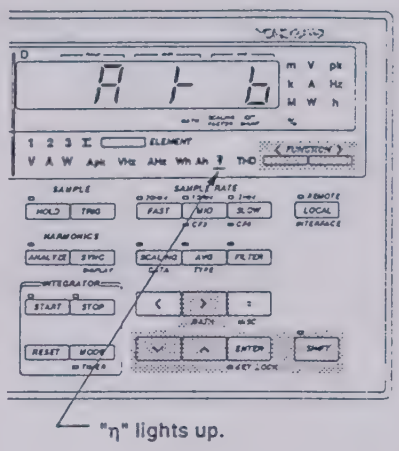
8.3 Four Arithmetical Operations Using Display D

When "η" (efficiency) is selected for display D, the MATH function enables the four arithmetical operations on the measured values displayed on displays A and B, and displays the result on display D.

Function Setting

Operating the *FUNCTION* Key

1. Press the ***FUNCTION*** key below display D to select "η" (efficiency).
   For details, refer to Section "4.3 Selecting what to Display on Digital Displays" (page 4-11.)



"η" lights up.

Setting the Computing Equation

2. Press the ***MATH*** key (***SHIFT*** + >).
3. Press the ∧ or ∨ key. The computing code on display D changes in the following order. Select one of the computing equations from "A + b", "A - b", "A ,, b", and "A ÷ b".

EFF , →[F U1→(CF U2)→[F U3→[F A1→(CF A2)→ [F A3→A + b→A - b →A ,, b→A ÷ b→EFF ,- - -

Symbols within brackets are displayed only on the three-phase, four-wire model (253130).

4. Press the ***ENTER*** key.

Note

- The computing codes displayed on display D are described as follows.
  + : + (addition)
  - : − (subtraction)
  ,, : × (multiplication)
  ÷ : ÷ (division)

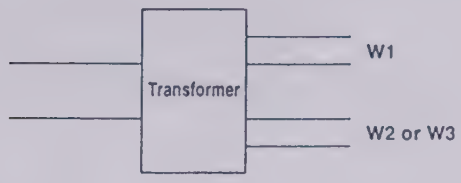
Application Examples

Addition of two measured values (power)

A + b : result of display A + display B is displayed.

Example:

Display A	Display B	Display D	Wiring System
W1	W2 or W3	W1 + W2 or W1 + W3	Any

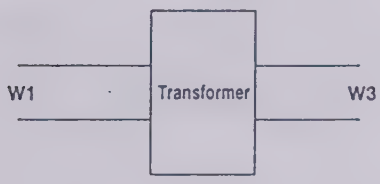


Computation of power loss

A - b : result of display A – display B is displayed.

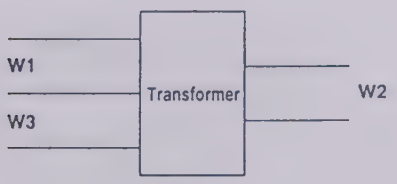
Example 1:

Display A	Display B	Display D	Wiring System
W1	W3	W1 – W3	Any



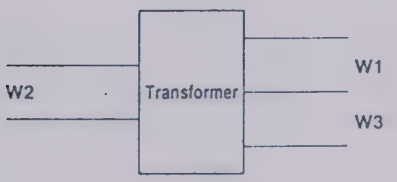
Example 2:

Display A	Display B	Display D	Wiring System
$\Sigma W (= W_1 + W_3)$	W2	$\Sigma W - W2$	3ø3W



Example 3:

Display A	Display B	Display D	Wiring System
W2	$\Sigma W (= W_1 + W_3)$	$W2 - \Sigma W$	3ø3W

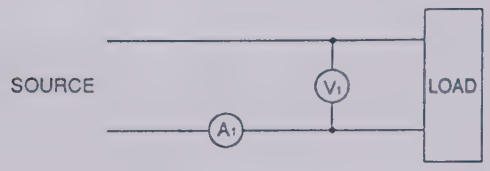


A * b : Result of display A × display B is displayed.
This can be used when a function other than VA (apparent power) is set for display C to display computed apparent power (VA) on display D.
Example:

Display A	Display B	Display D	Wiring System
V1 rms	A1 rms	V1 rms × A1 rms	Any

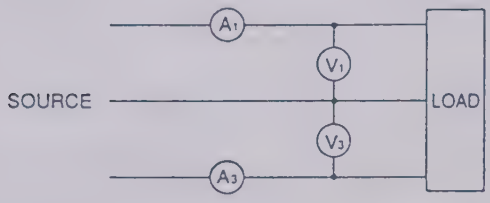
A / b : Result of display A ÷ display B is displayed.
This can be used to calculate impedance load.
Example 1:

Display A	Display B	Display D	Wiring System
V1 rms	A1 rms	$Z = \frac{V1\ rms}{A1\ rms}$	Any



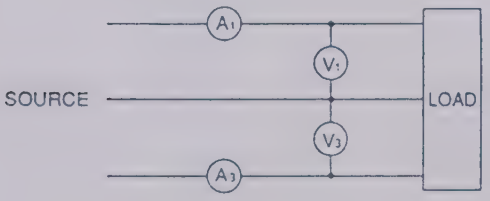
Example 2:

Display A	Display B	Display D	Wiring System
ΣV rms (= V1 rms + V3 rms)	ΣA rms (= A1 rms + A3 rms)	$\frac{\Sigma V\ rms}{\Sigma A\ rms}$	Any except 1ø2W



This can be also used to calculate the line voltage ratio or the phase current ratio of a three-phase wiring system.
Example 3:

Display A	Display B	Display D	Wiring System
V1 rms	V3 rms	$\frac{V1\ rms}{V3\ rms}$	3ø3W
A1 rms	A3 rms	$\frac{A1\ rms}{A3\ rms}$	



8.4 Using the Scaling Function

Overview of the Scaling Function

The scaling function multiplies measured values such as voltage, current and power by the scaling value and then displays the results. When measuring inputs that exceed the measuring range, an external potential transformer (PT) or current transformer (CT) is used. In this case, setting the scaling value to the PT ratio or CT ratio converts measured values to the corresponding values for the transformer primary side before they are displayed.

Display Item	Measured/Computed Value	Scaled Value
Voltage	V	Kv × V
Current	A	Ki × A
Active power	W	Kv × Ki × Kw × W
Reactive power	var	Kv × Ki × Kw × var
Apparent power	VA	Kv × Ki × Kw × VA

Kv : Voltage scaling value (PT ratio)
Ki : Current scaling value (CT ratio)
Kw : Scaling factor

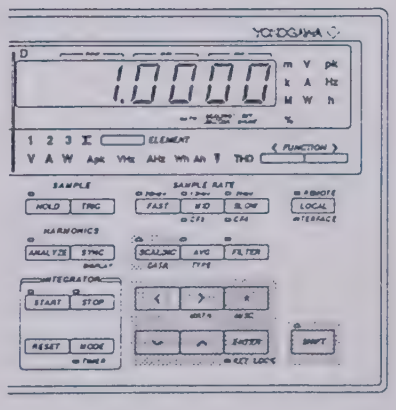
Note

- With the 2531 with ROM version of 2.01 or above, it is possible to set shunt scaling value at once for all elements or one by one for each element, as in the setting scaling value described in the next section. When making settings using communications commands, the "**CM**" command can be used to select either the use of a command used to make settings at once for all elements, or a command used to make settings one by one for each element.
  With the 2531 with ROM version of below 2.01, only settings at once for all elements can be made. If you attempt to use the "**CM**" command to make settings, error 11 will occur. To ascertain the ROM version of your instrument, refer to Section "2.5 Turning the Power ON or OFF" (page 2-8). For detailed information on "**CM**" command setting, refer to the Appendix (page 1).

Setting Scaling Values

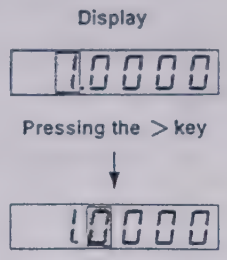
Setting the PT/CT Ratio and Scaling Factor

1. Press the *DATA* key (*SHIFT* + *SCALING*).
   The currently set element, PT ratio, CT ratio and scaling factor will be displayed on displays B, C and D respectively. Press the ∧ or ∨ key until the desired element is displayed on display A.
   The display changes in the order of ALL (all elements) → EL1 (element 1) → EL2 (element 2, applicable only for the 253130) → EL3 (element 3) → End (to end making setting) and back to ALL.
   The digit on the extreme left of the PT ratio (display B) will start blinking.

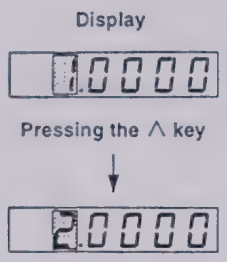


Follow steps 2 to 5 to set the PT ratio, CT ratio and scaling factor.

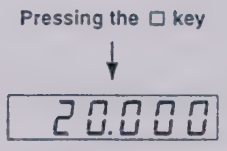
2. Shifting the blinking position
   The blinking position can be shifted to the left or right by pressing the < or > key respectively.



3. Setting a value
   To set the value of the blinking digit, press the ∧ or ∨ key.
   Pressing the ∧ key changes the value in the order 1, 2, 3 ... 9, 0 and back to 1.
   Pressing the ∨ key changes the value in the opposite direction.
   Default value (PT and CT): 1.0000
   Minimum value: 0.0001
   Maximum value: 10000



4. Shifting the decimal point position
   The decimal point can be shifted by pressing the □ key.



5. After setting of the PT ratio has been completed, press the ***ENTER*** key. The leftmost digit of the CT ratio now starts blinking.

6. When the ***ENTER*** key is pressed in step *5*, the next element is now displayed on display A. Repeat steps *2* to *5*.

7. To exit from setting mode, select "End" on display C and then press the ***ENTER*** key. To exit from setting mode in the middle of making settings, press the ***SHIFT*** key or ***SCALING*** (***DATA***) key.

Turning the Scaling Function ON

Press the ***SCALING*** key. The SCALING indicator LED will light up. To turn OFF scaling, press the ***SCALING*** key again. This causes the SCALING indicator LED to go out.

	Voltage	Current
Scaling OFF	PT secondary side	CT secondary side
Scaling ON	PT primary side	CT primary side

Note

- If an attempt is made to set a scaling value that is outside the setting range, error code "Err 12" is displayed on display D. In this case, enter a valid value.
- When an external shunt is used, refer to Section "4.2 Setting Measuring Ranges" (page 4-8).
- If the ***ENTER*** key is pressed while "ALL" is displayed on display A, the scaling value for each element will be set to the value displayed on displays B, C and D, and then setting mode ends.

Precautions When Setting Measuring Ranges with Scaling Function ON

If the scaled measured value exceeds 30000M (or 300000M in the case of integration), the following code will be displayed.

8.5 Using Averaging Functions

If reading measured values (power) is difficult due to fluctuations in the power source or load, or due to the low frequency of the measured signal, averaging functions can be used to stabilize the displayed values to make reading easier. Two types of averaging function are available with this instrument: exponential averaging and moving averaging.

Exponential Averaging

Exponential averaging is expressed by the following equation.

$$D_n = D_{n-1} + (M_n - D_{n-1}) / K$$

D_n (the value at the "n"th display) is obtained by subtracting D_{n-1} (obtained by applying exponential averaging to the values up to the "n – 1"th) from the measured value M_n, dividing the result by K (the attenuation constant), then adding the quotient to D_{n-1}.

Moving Averaging

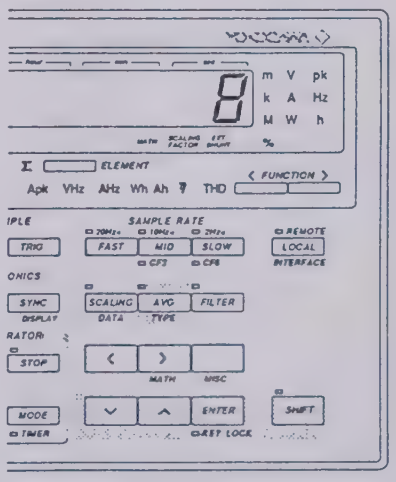
Moving averaging is expressed by the following equation.

$$D_n = (M_{n-(m-1)} + \ldots + M_{n-2} + M_{n-1} + M_n) / m$$

D_n is obtained by simply dividing the sum of the measured values including M_n by m (the number of data).

Setting Averaging Type

1. Press the ***TYPE*** key (***SHIFT*** + ***AVG***).
   Averaging type selection mode is now active.
2. Press the ∧ or ∨ key to select the averaging type.
   E P : Exponential averaging
   L in : Moving averaging
3. Press the ***ENTER*** key.



Setting the Attenuation Constant or Averaging Sample Number

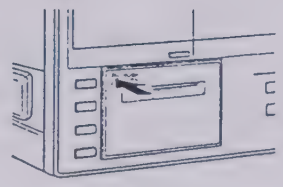
4. Press the ∧ or ∨ key to set an attenuation constant (K) or sample number (m).
   Exponential averaging : selectable attenuation constant (K) : 8, 16, 32, 64, 128, 256
   Moving averaging : selectable sample number (m) : 8, 16, 32, 64 128, 256
5. Press the ***ENTER*** key.

Starting Averaging Process

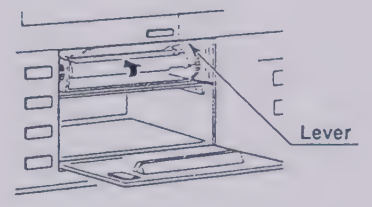
6. Press the ***AVG*** key.
   The AVG indicator LED lights up, indicating that the averaging function is ON. To turn OFF the averaging function, press the ***AVG*** key again. This causes the AVG indicator LED to go out.

9.1 Loading a Roll Chart (Optional)

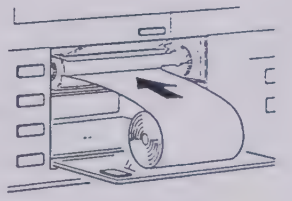
1. Press the left upper corner of the printer cover to open the cover.



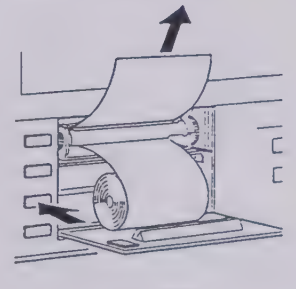
2. Lift the paper feed guide lever in the direction shown by the arrow to release the paper lock.



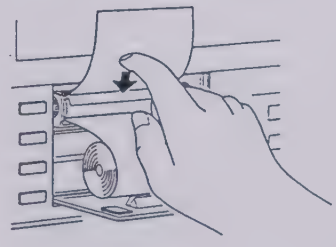
3. Insert the paper underneath the paper feed guide. Make sure that the paper is not skewed.
   Press the ***FEED*** key to feed the paper. (Make sure that the paper is fed in the direction as illustrated. If the paper is fed in the opposite direction, printing cannot be performed.)



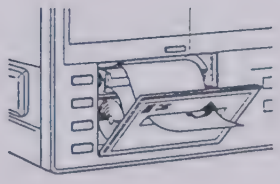
4. Hold down the ***FEED*** key until approximately 10 cm of the paper comes out of the top of the guide.



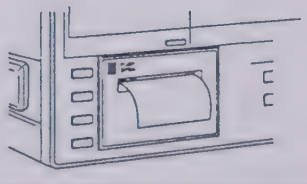
5. Push the middle of the guide in the direction shown by the arrow to secure the paper.



6. Place the paper inside the printer and pass the end of the paper through the slot in the printer cover.



7. Close the printer cover.
   To cut the paper, just pull it upwards. If the printer cover is opened after the cover has been closed and the paper cut, press the ***FEED*** key to feed the paper out and then carry out steps *6* and *7*.



Note

- Never press the ***FEED*** key if the PAPER ERROR LED is lit, except when loading a roll chart into the printer, otherwise a breakdown may result.

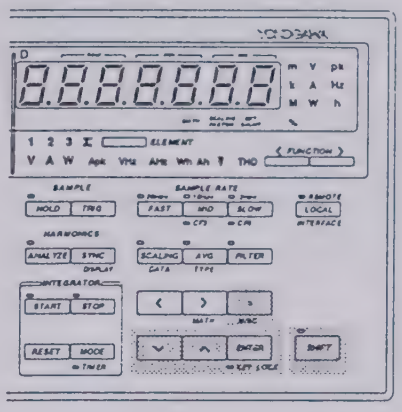
9.2 Setting Printer Output Functions (Optional)

Since the printer output functions are the same as the communications output functions, changing the printer output settings also changes the communications output settings. (For communications functions, refer to Chapter "11 Using the Communications Functions.") Up to 14 items can be set.

Selecting the Output Function Setting Menu

1. Press the *MISC* key (*SHIFT* + ▫).
   Press the ∧ or ∨ key to display "oUtPUt" on display D.

2. Press the *ENTER* key.
   The output function currently set will be displayed on display B.
   Default setting: "nor" (Output function for normal measurement)



Setting Output Function

3. Press the ∧ or ∨ key to select the desired output function.
   - PnL : Panel settings (set-up information) are printed. Refer to Section "9.3 Printing a Set-up Information List" (page 9-5.)
   - nor : Normal measurement (output items for normal measurement or integration measurement can be set as default settings, or desired output items can be set.)
   - HAr : Harmonic analysis (optional) (results of harmonic analysis are printed. For details, refer to the separate instruction manual.)

4. Press the *ENTER* key.

Setting Output Format

When "nor" is selected, the output format currently set is displayed on display B.

5. Press the ∧ or ∨ key to select the desired output format.
   Three output formats are available.
   dFLt-n : output items for normal measurement are set as default.
   dFLt-1 : output items for integration measurement are set as default.
   SEL : Desired output items can be set. Refer to "Output Channels and Output Items" on the next page.

6. Press the *ENTER* key.

Wiring System and Output Items when "dFLt-n" is Selected

Channel No.	1ø2W	3ø3W	3ø4W
01	V1	V1	V1
02			V2
03		V3	V3
04		ΣV	ΣV
05	A1	A1	A1
06			A2
07		A3	A3
08		ΣA	ΣA
09	W1	W1	W1
10			W2
11		W3	W3
12		ΣW	ΣW
13	Item displayed on display C is output.		
14	Item displayed on display D is output.		

Wiring System and Output Items When "dFLt-1" is Selected

Channel No.	1ø2W	3ø3W	3ø4W
01	W1	W1	W1
02			W2
03		W3	W3
04		ΣW	ΣW
05	Wh1	Wh1	Wh1
06			Wh2
07		Wh3	Wh3
08		ΣWh	ΣWh
09	Ah1	Ah1	Ah1
10			Ah2
11		Ah3	Ah3
12		ΣAh	ΣAh
13	Hz	Hz	Hz
14	HM	HM	HM

Hz : Measured frequency
HM: Elapsed time of integration

Output Channels and Output Information Type

If "SEL" is selected, the channel and output information type setting mode is activated.
A channel no. is displayed on display C, and the output item and element currently set are displayed on display D.

Display B	Display C	Display D
nor	ch 1	U 1

1. Press the ∧ or ∨ key to set the desired channel.

2. Press the *ENTER* key.
   The output information type displayed on display D will start blinking.

Setting Output Information Types and Elements

3. Use the ∧, ∨, < and > keys to set the desired output information type and element.

Output Items which can be Set

U	(V)	A	(A)
P	(W)	UAr	(var)
UA	(VA)	PF	
UFrq	(VHz)	AFrq	(AHz)
Ph	(Wh)	Ah	(Ah)
dEG	(deg)	UP	(V peak)
AP	(A peak)	EFF,	(Efficiency)
Et	(Elapsed time of integration)		
---	(No output)		

Elements Which can be Set

1 : Element 1
2 : Element 2
3 : Element 3
4 : Element Σ
For certain output types, no element can be set. (no output, efficiency and elapsed time of integration)

4. Press the *ENTER* key.
   The next channel no. will be displayed on display C.

5. Repeat steps *1* to *4* to set the desired output type and element for each channel.

6. To exit from the channel and output information type setting mode, follow the procedure below.
   After all 14 channels have been set, "End" is displayed on display C. To quit setting mode, press the *ENTER* key. To continue making settings, press the ∧ or ∨ key to select the desired channel no.
   To exit from setting mode in the middle of making settings, press the ▫ (*MISC*) or *SHIFT* key.

9.3 Printing a Set-up Information List (Optional)

Set-up Information which can be Printed

Set-up information which can be printed are given below.

1) Model name
2) Voltage range and measuring mode selected for each element
3) Current range and measuring mode selected for each element
4) External shunt set-up information
5) Elements to be displayed
6) Wiring system
7) Filter ON/OFF
8) Crest factor
9) Scaling ON/OFF and set-up information
10) Averaging ON/OFF, averaging type and attenuation constant
11) Hold ON/OFF
12) Sample rate
13) MATH function set-up information
14) Integration mode and timer preset time
15) Rated integration time for D/A outputs
16) Print mode and print interval
17) Harmonic analysis display mode, PLL source
18) Command groups

Set-up information items 15) to 17) can be printed only when the corresponding options are present.

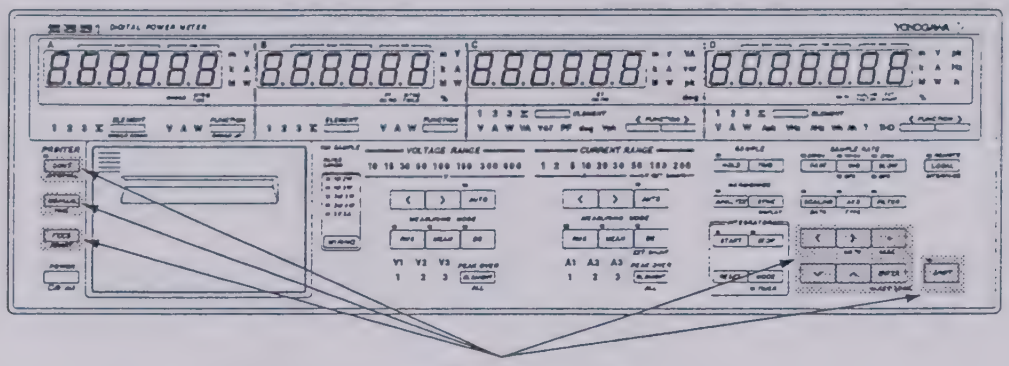
The output format is the same as that used by the OS communications command, except that in the case of communications "END" is printed on the last line.

Print Set-up

1. Press the ***MISC*** key (***SHIFT*** + ▫). Press the ∧ or ∨ key to display "outPut" on display D.
2. Press the ***ENTER*** key.
3. Press the ∧ or ∨ key to display "Prt" on display B.
4. Press the ***ENTER*** key. Measurement is resumed.

9.4 Printing Measured Values in Manual or Auto Print Mode (Optional)

Keys used for Printing



These keys are used.

Printing Measured Values in Manual Print Mode

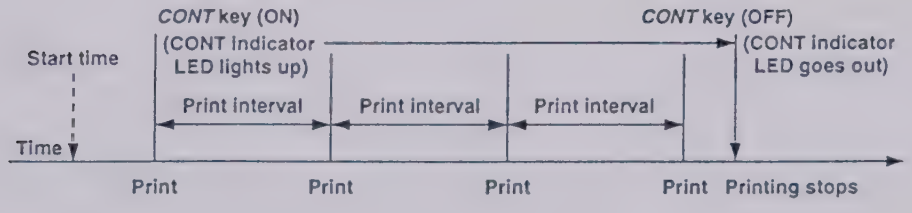
Procedure

1. Press the ***MANUAL*** key.
   The printer will begin to print out measured values.
   The ***MANUAL*** key is also valid in auto print mode.

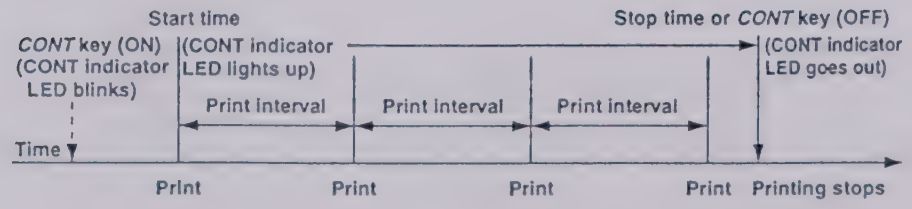
Printing Measured Values in Auto Print Mode

In auto print mode, measured values are printed out automatically at print intervals. Setting the auto print start/stop time enables printing of measured values at the desired time.
Print timing charts for the ***CONT*** key and for a preset start/stop time are given below.

Print timing using the *CONT* key



Print timing using a preset start/stop time



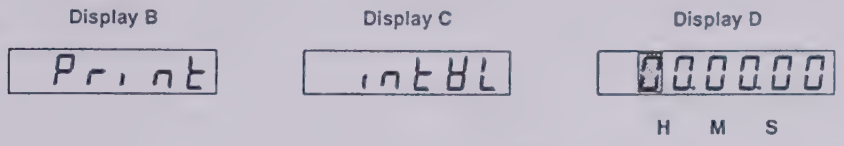
Note

- If the preset stop time has already passed when the ***CONT*** key is pressed, error code "E r r 1 7" will be displayed.

Setting the Print Interval

In auto print mode, measured values are printed out automatically at intervals. Set the print interval as follows.

1. Press the *INTERVAL* key (*SHIFT* + *CONT*).
   The leftmost digit of display D will begin to blink.

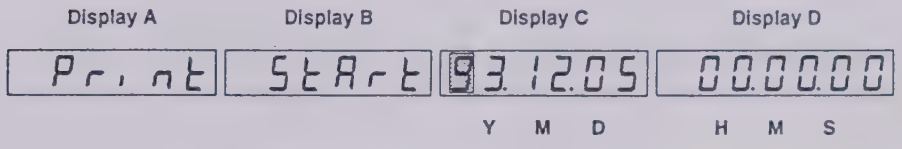


2. Use the ∧, ∨, < and > keys to set the desired print interval.
   Minimum interval allowed : 10 s (Error code "Err 12" will be displayed if a value below 10 s is set.)
   Allowable maximum interval : 99 h 59 m 59 s

3. Press the *ENTER* key.

Setting the Auto Print Start/Stop Time

1. Press the *TIME* key (*SHIFT* + *MANUAL*).
   The leftmost digit of display C begins to blink.



2. Set the desired print start date using the ∧, ∨, < and > keys.

3. Press the *ENTER* key.
   The leftmost digit of display D now begins to blink.

4. Set the desired print start time using the ∧, ∨, < and > keys.

5. Press the *ENTER* key.
   "StoP" is now displayed on display B.

6. Repeat steps *2* to *5* to set the stop date and time.

Executing Auto Print

After the print interval, or the print interval and auto print start/stop date and time have been set, auto printing can be executed as follows.

1. Press the *CONT* key.
   The CONT indicator LED will light up, indicating that the auto print function is ready. Auto printing will be executed according to the settings made. Pressing the *CONT* key will cause the LED to go out.

Stopping Print Out

To stop printing while printing is in progress, press the *ABORT* key (*SHIFT* + *FEED*).

10.1 External Input/Output Signals (Remote Control, D/A Output)

Use of external input/output signals enables remote control of the instrument as well as output of analog signals from the D/A converter (optional).

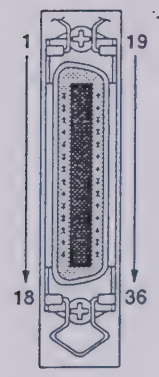
Signal Input/Output Function

The remote control/analog output connector can be used for the following purposes.

- To start, stop and reset integration (*INTEGRATOR START*, *STOP* and *RESET* keys)
  → Refer to Section "10.2 Remote Control" (page 10-2.)
- To hold and update displayed data (*SAMPLE HOLD* and *TRIG* keys)
  → Refer to Section "10.2 Remote Control" (page 10-2).
- To output measured/computed data as an analog signal
  → Refer to Section "10.3 D/A Output (Optional)" (page 10-3).

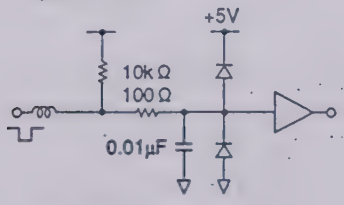
Pin Assignment

The table below shows the pin assignment of the remote control/analog output connector.



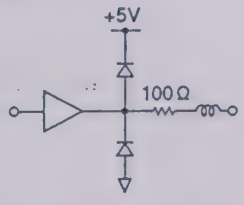
Pin No.	Signal Name	Pin No.	Signal Name
1	DIG COM	19	DIG COM
2	EXT HOLD (input)	20	EXT TRIG (input)
3	EXT START (input)	21	EXT STOP (input)
4	EXT RESET (input)	22	INTEG BUSY (output)
5	EXT PRINT (input)	23	N.C.
6	N.C.	24	N.C.
7	N.C.	25	N.C.
8	N.C.	26	N.C.
9	N.C.	27	N.C.
10	D/A COM	28	D/A COM
11	D/A COM	29	D/A COM
12	CH1 (output)	30	CH2 (output)
13	CH3 (output)	31	CH4 (output)
14	CH5 (output)	32	CH6 (output)
15	CH7 (output)	33	CH8 (output)
16	CH9 (output)	34	CH10 (output)
17	CH11 (output)	35	CH12 (output)
18	CH13 (output)	36	CH14 (output)

Remote Control Input Circuit



TTL level
L: 0 to 0.8 V
H: 2.0 to 5 V

Remote Control Output Circuit



TTL level
L: 0 to 0.4 V (8 mA)
H: 2.4 to 5 V (-400 μA)

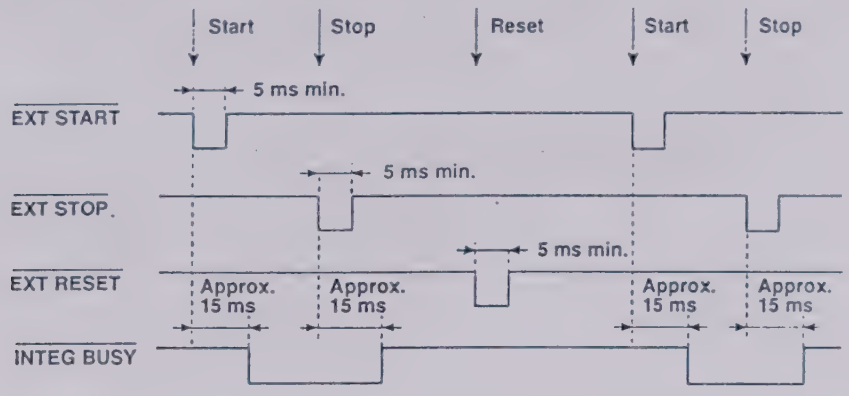
Note

- For the location of the connector, refer to Section "1.4 Part Descriptions and Functions" (page 1-6).
- For D/A outputs, refer to Section "10.3 D/A Output (Optional)" (page 10-3).

10.2 Remote Control

Controlling Integration

To control integration, apply signals according to the timing chart below.

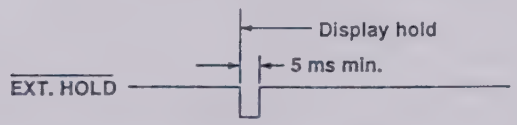


As shown in the timing chart, the $\overline{\text{INTEG BUSY}}$ output signal level goes low while integration is in progress. This signal can be used to monitor integration etc.

Holding Display Data Update and Updating Display Data

Holding Display Data Update (same function as *SAMPLE HOLD* key)

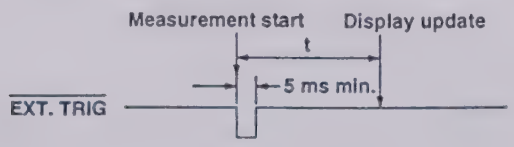
To hold the display data update, apply the $\overline{\text{EXT HOLD}}$ signal according to the timing chart below.



Updating Display Data (same function as *SAMPLE TRIG* key)

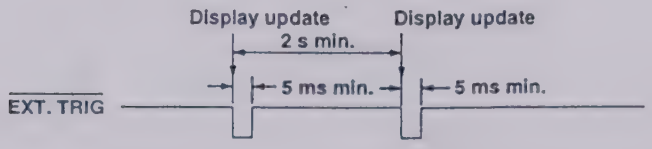
Applying an $\overline{\text{EXT TRIG}}$ signal when the display data is on hold updates the display data.

Update timing during normal measurement



t: 0.25 s min. when SAMPLE RATE is set to FAST
0.5 s min. when SAMPLE RATE is set to MID
2 s min. when SAMPLE RATE is set to SLOW

Update timing during integration



Note

- For a description of each signal, refer to Section "1.3 Functions" (page 1-4).
- For the pin assignment, refer to Section "10.1 External Input/Output Signals (Remote Control, D/A Output)" (page 10-1).

10.3 D/A Output (Optional)

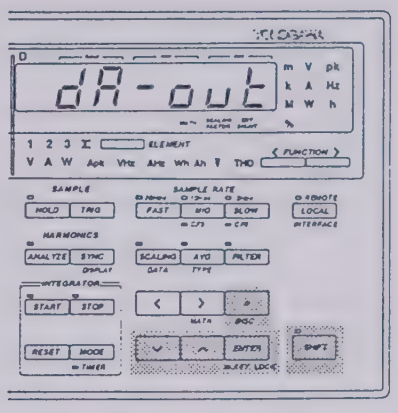
Setting D/A Output

Measured/computed data can be output as an analog signal from the remote control/analog output connector on the rear panel. Up to 14 items (14 channels) can be output.

Selecting the D/A Output Setting Menu

1. Press the *MISC* key (*SHIFT* + ₀).
   Press the ∧ or ∨ key to display "dA-out" on display D.

2. Press the *ENTER* key.



Setting Output Format

3. Press the ∧ or ∨ key to select the desired output format.
   - dFLt-n : output items for normal measurement are set as default.
   - dFLt-i : output items for integration measurement are set as default.
   - SEL : desired output items can be set.

4. Press the *ENTER* key.
   If "SEL" is selected, the D/A output channel setting screen is displayed on display C, and the D/A output item and element setting screen is displayed on display D.

Display C	Display D
ch 1	U 1

Setting D/A Output Channel

5. Press the ∧ or ∨ key to set the desired channel.
   After the channel has been set, set the output type and element on display D.

6. Press the *ENTER* key.

Setting Information Type and Elements

7. Use the ∧, ∨, < and > keys to set the desired output type and element.

Output Information Types which can be Set

U	(V)	A	(A)
P	(W)	UAr	(var)
UA	(VA)	PF	
UFq	(VHz)	AFq	(AHz)
Ph	(Wh)	Ah	(Ah)
dEG	(deg)	UP	(V peak)
AP	(A peak)		
EFF	(Efficiency)		
---	(No output)		

Elements which can be Set

1 : Element 1
2 : Element 2
3 : Element 3
4 : Element Σ
For certain output types (no output and efficiency), no element can be set.

8. Press the *ENTER* key.
The next channel no. will be displayed on display C.

9. Repeat steps *5* to *8* to set the desired output type and element for each channel.

Quitting Setting Mode

10. To exit from setting mode, follow the procedure below.
After all 14 channels have been set, "End" is displayed on display C. To quit setting mode, press the *ENTER* key. To continue making settings, press the ∧ or ∨ key to select the desired channel no.
To exit from setting mode in the middle of making settings, press the ▫ or *SHIFT* key.

Note

- When "EFF " (efficiency) is selected, 0 V is output from the D/A converter unless "EFF " is selected as the MATH function.
- If the scaling value has been set for voltage, current, power and external shunt, a voltage of 5.0 V (full scale) will be output from the D/A converter when the rated value is input.
- If the scaling values set for each element differ from each other in the case of element Σ, the number of display digits will be limited so that Σ value does not exceed 30000 (crest factor: 3) or 10000 (crest factor: 6) when the rated value is input to each corresponding element. A voltage of 5 V (full scale) will be output from the D/A converter as the Σ value obtained when the rated value is input to each corresponding element.

Wiring System and Output Information Types when "dFLt-n" is Selected

Channel No.	1ø2W	3ø3W	3ø4W
01	V1	V1	V1
02			V2
03		V3	V3
04		ΣV	ΣV
05	A1	A1	A1
06			A2
07		A3	A3
08		ΣA	ΣA
09	W1	W1	W1
10			W2
11		W3	W3
12		ΣW	ΣW
13	Item displayed on display C is output.		
14	Item displayed on display D is output.		

Wiring System and Output Information Types when "dFLt-1" is Selected

Channel No.	1ø2W	3ø3W	3ø4W
01	W1	W1	W1
02			W2
03		W3	W3
04		ΣW	ΣW
05	Wh1	Wh1	Wh1
06			Wh2
07		Wh3	Wh3
08		ΣWh	ΣWh
09	Ah1	Ah1	Ah1
10			Ah2
11		Ah3	Ah3
12		ΣAh	ΣAh
13	Hz	Hz	Hz
14			

Hz : Measured frequency

Setting Rated Integration Time when Outputting Integrated Values from the D/A Converter

1. Press the *MISC* key (*SHIFT* + ▫).
   Press the ∧ or ∨ key to display "itG-t" on display D.

2. Press the *ENTER* key.
   The rated integration time currently set will be displayed on display B. Set the desired time using the ∧, ∨, < and > keys.
   Minimum time allowed : 1 minute
   Maximum time allowed : 999 hours 59 minutes

   Display B

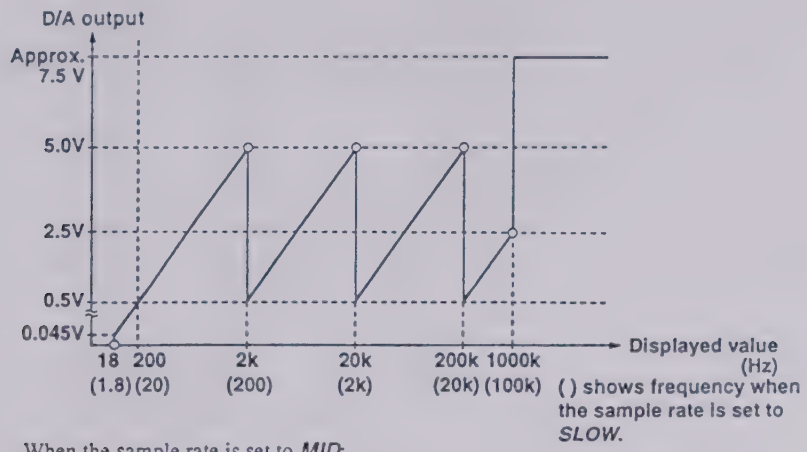
   H M

3. When the rated integration time has been set, press the *ENTER* key.

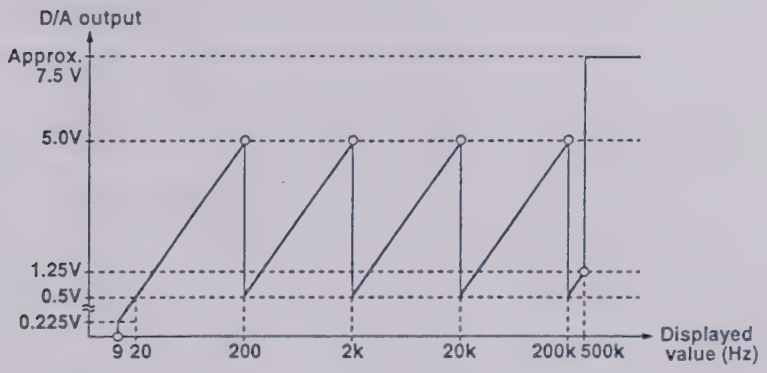
Output Information Types and D/A Output Voltage

Frequency

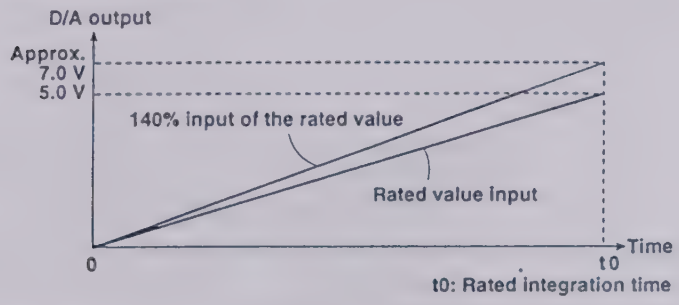
When the sample rate is set to *FAST* (or *SLOW*):



When the sample rate is set to *MID*:



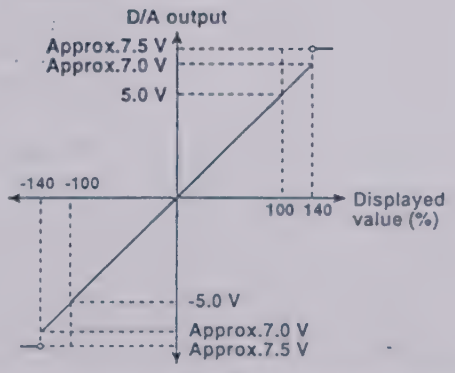
Integrated Value



Other Items

Displayed Value	Output
140%	Approx. 7.0 V
100%	5.0 V
0%	0 V
−100%	−5.0 V
−140%	Approx. −7.0 V

The maximum output level is ±5.0 V for power factor and phase angle. However, the output will be approx. ±7.5 V if there is an error.



11.1 Using the GP-IB Interface

The instrument is equipped with a GP-IB interface in accordance with your preference. This interface permits remote control from a controller such as a personal computer, and output of various data.

Overview of the GP-IB Interface

The table below shows functions that are available in each mode.

Mode	Function	
Addressable mode (mode A and mode B)	Listener	· Functions performed by front panel key operations (except for *LOCAL* key and power ON/OFF) · Measured/computed data output request · Panel set-up information output request · Error code output request
	Talker	· Measured/computed data output · Panel set-up information output · Error code output · Status byte output
Talk-only mode	Talker	Measured/computed data output

Addressable Mode A

Measured data is output when an "OD" (measured data output request command) is received. This mode enables transmission of measured data at a specified time.

Addressable Mode B

This mode does not require a measured data inquiry command. When measured data is requested by the controller (personal computer etc.), the data is output as the display is updated when measurement is completed. Therefore, if an attempt is made to transmit measured data at intervals shorter than the display intervals, the controller is forced to wait until the next display interval.

Talk-only Mode

This mode does not require a controller. Measured data is output at certain intervals. The interval can be set to any length. This mode is useful when the instrument is connected to a listener-only device such as a printer.

GP-IB Interface Specifications

Electrical and mechanical specifications : conforms to IEEE Std 488-1978
Functional specifications : refer to the table blow.
Code : ISO (ASCII) code
Address setting : listener and talker addresses 0 to 31 or talk-only can be selected using the front panel keys.
Remote mode clear : remote mode can be cleared by pressing the *LOCAL* key on the front panel. However, this is not possible if Local Lockout has been set by the controller.

Function	Subset Name	Description
Source handshaking	SH1	Full source handshake capability
Acceptor handshaking	AH1	Full acceptor handshake capability
Talker	T5	Basic talker capability, serial polling, untalk on MLA (My Listen Address), talk-only capability
Listener	L4	Basic listener capability, unlisten on MTA (My Talk Address), no listen-only capability
Service request	SR1	Full service request capability
Remote local	RL1	Full remote/local capability
Parallel poll	PP0	No parallel polling capability
Device clear	DC1	Full device clear capability
Device trigger	DT1	Full device trigger capability
Controller	C0	No controller function

Response to Interface Messages

IFC (Interface Clear)

Cancels (unaddresses) talker and listener.

REN (Remote Enable)

Transfers the instrument from local control to remote control.

GTL (Go To Local)

Transfers the instrument from remote control to local control.

SDC (Selective Device Clear), DCL (Device Clear)

Clears GP-IB input/output buffer, and resets an error. The set-up information and measurement state are not affected.
DCL is applicable to all devices on the bus, whilst DSC is applicable only to designated devices.

GET (Group Execute Trigger)

Same function as the *TRIG* key

LLO (Local Lockout)

Invalidates the *LOCAL* key on the front panel to inhibit transfer from remote control to local control.

Switching between Remote and Local Mode

When Transferred from Local to Remote Mode

The REMOTE indicator LED will light up. All front panel keys except the *LOCAL* key cannot be operated any more. Set-up information entered in local mode is retained.

When Transferred from Remote to Local Mode

The REMOTE indicator LED will go out. All front panel keys can be operated. Set-up information entered in remote mode is retained.

Valid Keys for Remote Control

Pressing the *LOCAL* key in remote control transfers the instrument to local control. However, this is not possible if Local Lockout has been set by the controller.

Status Byte Format

DI08	DI07	DI06	DI05	DI04	DI03	DI02	DI01
Integration BUSY	SRQ	ERROR	Printer BUSY	OVER	Syntax ERROR	Integration END	Computation END

Integration BUSY (DIO 8)

This bit is set to "1" when integration is in progress. This bit cannot be disabled by the IM command since it is a status bit. Even if this bit is set to "1", SRQ will not be affected.

SRQ (DIO7)

This bit is set to "1" when computation END (DIO 1), integration END (DIO 2), OVER (DIO 4) or syntax ERROR (DIO 3) occurs. When RQS is set to "1", SRQ is set to True, issuing a service request to the controller. This bit is reset to "0" when a response is sent to the serial poll. To prevent the SRQ and status byte being affected by computation END, integration END, OVER or syntax ERROR, this bit must be disabled by the IM command.
After an "IM15", SRQ is affected by a computation END, integration END, syntax ERROR or OVER.
After an "IM1", SRQ is affected only by a computation END.
In the case of "IM4", the SRQ is affected only by a syntax ERROR.

ERROR (DIO 6)

When a syntax ERROR or OVER occurs, this bit is set to "1" and the SRQ is set to TRUE.

Printer BUSY (DIO 5)

This bit is set to "1" when printing of data is in progress. This bit cannot be disabled by the IM command since it is a status bit. Even if this bit is set to "1", SRQ will not be affected.

OVER (DIO 4)

This bit is set to "1" and the SRQ is set to True when an overrange occurs in the measured data. However, this is not valid if the bit has been disabled by the IM command. This bit is reset after a response is made to the serial poll. The nature of OVER can be identified by the OE command.

Syntax ERROR (DIO 3)

This bit is set to "1" when a command error, parameter error or execution error occurs. The error no. can be identified by the OE command. This bit is reset after a response is made to the serial poll. However, this is not valid if the bit has been disabled by the IM command.

Integration END (DIO 2)

This bit is set to "1" when integration has been completed. The bit is reset when a response is made to the serial poll. However, this is not valid if the bit has been disabled by the IM command.

Computation END (DIO 1)

This bit is set to "1" when computation has been completed and the display is updated. The bit is reset when a response is made to the serial poll. However, this is not valid if the bit has been disabled by the IM command.

Output Format for Measured/Computed Data

Data Format

Measured data normally consists of a 6-byte header and 11 bytes of data.

Header	Data

Header Section

The header section consists of six bytes (h1 to h6.)

h1	h2	h3	h4	h5	h6

h1 to h3 : Data type

- V_ : Voltage
- A_ : Current
- W_ : Power
- VA_ : Apparent power
- Var : Reactive power
- PF_ : Power factor
- HzV : Voltage frequency
- HzA : Current frequency
- Wh_ : Watt-hour
- Ah_ : Ampere-hour
- DEG : Phase angle
- Vpk : Peak voltage
- Apk : Peak current
- EFF : Efficiency
- HM_ : Elapsed time of integration
- CV1 : Crest factor of V1
- CV2 : Crest factor of V2
- CV3 : Crest factor of V3
- CA1 : Crest factor of A1
- CA2 : Crest factor of A2
- CA3 : Crest factor of A3
- A + B: Value on display A + Value on display B
- A – B: Value on display A – Value on display B
- A * B: Value on display A * Value on display B
- A / B : Value on display A / Value on display B

h4: Element

- 1 : Element 1
- 2 : Element 2
- 3 : Element 3
- 4 : Σ

h5: Data state

- N : Normal
- I : Overrange
- O : Computation overflow
- P : Peak overflow
- E : No data

h6: Indicates phase lead or lag when the data type is PF_ (power factor) or DEG (phase angle.)

- G : Lag
- D : Lead
- _ : Not detectable

Data Section

The data section consists of 11 bytes (d1 to d11.)

d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11

d1 : Polarity : _ (space) or – (minus)

d2 to d8 : Floating-point number (maximum six digits)

d9 to d11 : Exponent

- E – 3 → m
- E + 0
- E + 3 → k
- E + 6 → M

Data state in the case of an overrange ("-oL-" is displayed.)

h1	h2	h3	h4	I	_	_	9	9	9	9	9	9	.	E	+	3

Data state in the case of a computation overflow ("-oF-" is displayed.)

h1	h2	h3	h4	I	_	_	8	8	8	8	8	8	.	E	+	0

Elapsed time of integration

H	M	_	_	_	_	d1	d2	d3	d4	d5	d6	d7	d8	d9

d1 to d3 : Hour
d4 : ":"
d5 to d6 : Minute
d7 : ":"
d8 to d9 : Second

Output Format when "SEL" is Selected

Up to 14 measured data can be output simultaneously, and the user is allowed to choose any output information type for those 14 data. Each output block is of the following format.

Line 1	ch.1	,	ch.2	,	ch.3	,	ch.4	Terminator
Line 2	ch.5	,	ch.6	,	ch.7	,	ch.8	Terminator
Line 3	ch.9	,	ch.10	,	ch.11	,	ch.12	Terminator
Line 4	ch.13	,	ch.14	Terminator				
Line 5	END	Terminator						

Each output block normally consists of 5 lines including the block end line ("END".) However, if all output types on a line are set to "no output", this line will be omitted, reducing the number of output lines to 4. For instance, if all output items (ch.9 to ch.12) are set to "no output", line 3 will be omitted.

Furthermore, if any channel on a line is set to "no output", all data following this channel on the line will be shifted forward. For instance, if ch.2 on line 1 is set to "no output", ch.1 will be followed immediately by the data for ch.3.

Default Output Format for Normal Measurement

Three-phase three-wire model (253120)

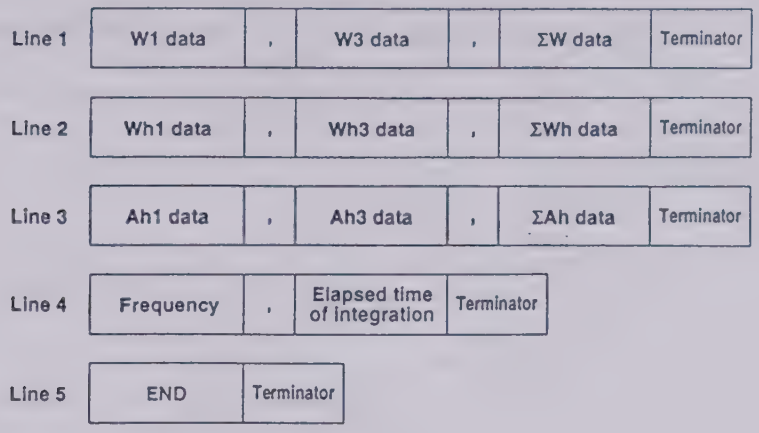
Line 1	V1 data	,	V3 data	,	ΣV data	Terminator			
Line 2	A1 data	,	A3 data	,	ΣA data	Terminator			
Line 3	W1 data	,	W3 data	,	ΣW data	Terminator			
Line 4	Display C	,	Display D	Terminator					
Line 5	END	Terminator							

Three-phase, four-wire model (253130)

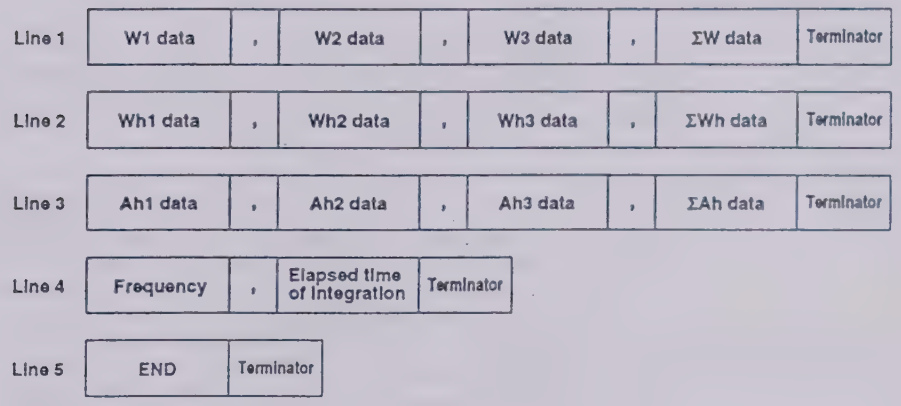
Line 1	V1 data	,	V2 data	,	V3 data	,	ΣV data	Terminator	
Line 2	A1 data	,	A2 data	,	A3 data	,	ΣA data	Terminator	
Line 3	W1 data	,	W2 data	,	W3 data	,	ΣW data	Terminator	
Line 4	Display C	,	Display D	Terminator					
Line 5	END	Terminator							

Default Output Format for Integration Measurement

Three-phase, three-wire model (253120)



Three-phase, four-wire model (253130)



Output Format for Set-up Information/Error Codes

Refer to the application examples of the "OS" and "OE" commands given in the Appendix. To see the contents of the displays in these examples, refer also to the description of the commands given in the Appendix.

Setting the Address/Addressable Mode

Before Operation

Setting the Address

A particular address is assigned to each device connected to the GP-IB interface so that each device can be recognized by every device. Therefore, an address must be assigned to this instrument when it is connected to a personal computer.
If this instrument is to be used with a listen-only device, the address of this instrument must be set to talk-only.

Address Setting Range

Any address from 0 to 31 can be set.
The factory setting is "1".
Once the address is set, it will remain unchanged even if the instrument is initialized.

Terminator

- **When this instrument is used as a listener**
  Use "CR + LF", "LF" or "EOI" as the receiving terminator.
- **When this instrument is used as a talker**
  The sending terminator is set using the DL command. The default setting is "CR + LF + EOI".

Talk-only Function

This function only allows the instrument to send data to other devices. If "talk-only" is off, the instrument can both send and receive data. In "talk-only" mode, the instrument cannot be controlled by the controller.

Note

- It is not possible for this instrument to receive data if the "CR" terminator is sent from the controller. It is also not possible to set "CR" as the terminator which is to be sent from this instrument.

Procedure

1. Press the ***LOCAL*** key.
   If the instrument is not in remote status, the addressable mode setting screen will be displayed on display C. Select the addressable mode using the ∧ or ∨ key.
   The addressable mode is switched in the following order "Addr A", "Addr b", "tonLy" and back to "Addr A".

   If the instrument has been in remote status, the instrument will be put in local status, but the addressable mode setting screen will not be displayed.

2. Press the ***ENTER*** key and select "Addr A" or "Addr b".
   When the selection is acknowledged, the address setting screen is displayed on display D. Set the address using the ∧, ∨, < and > keys, then press the ***ENTER*** key.

   To place the instrument in talk-only mode, select "tonLy".

Commands

For detailed description of each command, refer to the Appendix.

	Command	Action
Wiring system	WRm (WiRing)	Sets wiring system.
Voltage range	RV m,n (Range Voltage)	Sets voltage range.
	AV m,n (Auto Voltage range)	Sets voltage auto range.
Current range	RA m,n (Range current(A) range)	Sets current range.
	AA m,n (Auto current(A) range)	Sets current auto range.
	SAn or SAm,n (Shunt Ampere)	Sets external shunt current value.
Measurement mode	MV m,n (rms/Mean/dc Voltage)	Sets RMS/MEAN/DC mode for voltage measurement.
	MA m,n (rms/Mean/dc current(A))	Sets RMS/MEAN/DC mode for current measurement.
Filter	FLm (FiLter)	Sets filter ON or OFF.
Crest factor	CFm (Crest Factor)	Sets crest factor (3 or 6).
Sampling	SI m (Sampling Interval)	Sets sample rate.
	HD m (sampling HolD)	Holds display and output data.
	E or ST or <GET>	Trigger
Display	DA m (Display A function)	Selects function to be displayed on display A.
	DB m (Display B function)	Selects function to be displayed on display B.
	DC m (Display C function)	Selects function to be displayed on display C.
	DD m (Display D function)	Selects function to be displayed on display D.
	EA m (Element display A)	Selects element to be displayed on display A.
	EB m (Element display B)	Selects element to be displayed on display B.
	EC m (Element display C)	Selects element to be displayed on display C.
	ED m (Element display D)	Selects element to be displayed on display D.
Integration	IS (Integrate Start)	Starts integration.
	IP (Integrate Stop)	Stops integration.
	IR (Integrate Reset)	Resets integrated value.
	IC m (Integrate Continuous)	Sets integration mode.
	TM m1,m2 (integrate TiMer)	Sets integration timer preset time.
	IT m1/m2/m3/m4/m5/m6/, m7/m8/m9/m10/m11/m12 (Integrate real Time)	Sets integration start time and stop time.
Phase angle display	DGm (DeGree)	Sets phase angle display method.
Scaling	SC m (SCaling)	Sets scaling function ON or OFF.
	KVn or KVm,n (K*Voltage)	Sets scaling constant.
	KAn or KAm,n (K*Ampere)	
	KWn or KWm,n (K*Wattage)	
Averaging	AG m (AveraGing)	Sets averaging function ON or OFF.
	AT m (Averaging Type)	Selects exponential averaging or moving averaging.
	AC m (Averaging Coefficient)	Sets attenuation constant or averaging number.
MATH	MT m (Mathematics)	Sets computing equation.
Communications		
Command group	CMm (Communication coMand)	Sets command group to be used.
	OD (Output Data)	Requests output of measured data.
	OF m1,m2,m3 (Output Function)	Sets output items.
	OFD m (Output Function Default)	Sets default output items.
	OS (Output panel Setting)	Requests output of panel set-up information.
	OE (Output Error code)	Requests for output of error code.
	H m (Header)	Sets output data header.
	DL m (DeLimiter)	Selects output data delimiter.
	IM m (Interrupt Mask)	Sets status byte interrupt cause mask.
Other	DT m1,m2,m3 (DaTe)	Sets date.
	TI m1,m2,m3 (TIme)	Sets time.
	SL m (panel Setting Load)	Loads panel set-up information.
	SS m (panel Setting Store)	Stores panel set-up information.
	RC (Reset Command)	Initializes panel set-up information.

Options

Printer	PO (Print Out)	Requests print out.
	FD m (paper FeeD)	Requests paper feed.
	AB (print ABort)	Requests print abort.
	OF m1,m2,m3 (Output Function)	Sets output information type.
	PR m (PRinter)	Sets auto print function ON or OFF.
	PI m1,m2,m3 (Print Interval)	Sets print interval for auto print.
	PT m1/m2/m3/m4/m5/m6/, m7/m8/m9/m10/m11/m12	Sets auto print ON/OFF time.
	PP (Print Panel setting)	Prints out panel set-up information.
D/A	OA m1,m2,m3 (Output Analog) OAD	Sets D/A output information type.
	RT m1,m2 (integrate Rated Time)	Sets rated integration time for integrated values and D/A outputs.

11.2 Using the RS-232-C Interface

The instrument is equipped with an RS-232-C interface in accordance with your preference. This interface permits remote control from a controller such as a personal computer, and output of various data.

Overview of the RS-232-C Interface

The table below shows functions that are available in each mode.

Mode	Function	
Normal mode	Reception	· Functions performed using front panel key operations (except for *LOCAL* key and power ON/OFF) · Measured/computed data output request · Panel set-up information output request · Error code output request
	Transmission	· Measured/computed data output · Panel set-up information output · Error code output · Status byte output
Talk-only mode	Transmission	Measured/computed data output

Normal Mode

This mode is equivalent to addressable mode A of the GP-IB interface function, and enables reception of commands and transmission of measured data. Measured data is output on reception of the OD command.

Talk-only Mode

This mode is equivalent to the talk-only mode of the GP-IB interface function. Only transmission of measured data is allowed. No commands can be received.

There is no mode that is equivalent to the addressable mode B of the GP-IB interface function with this instrument.

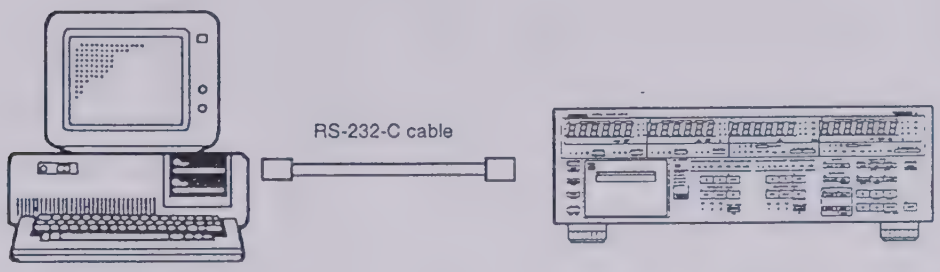
RS-232-C Interface Specifications

- Electrical characteristics : Conforms to EIA RS-232-C.
- Connection : Point-to-point
- Communications : Full-duplex
- Synchronization : Start-stop system
- Baud Rate : 75, 150, 300, 600, 1200, 2400, 4800 and 9600
- Start Bit : 1 bit
- Data Length (Word Length) : 7 or 8 bits
- Parity : Even, odd or no parity
- Stop Bit : 1 or 2 bits
- Software Handshaking : User can select whether CA, CB, CC and CD signals will always be True, or be used for control.
- Software Handshaking : User can select whether to control only transmission or both transmission and reception using X-on and X-off signals.
  X-on : ASCII 11H
  X-off : ASCII 13H
- Receive Buffer Size : 64 bytes

Connecting the RS-232-C Interface Cable

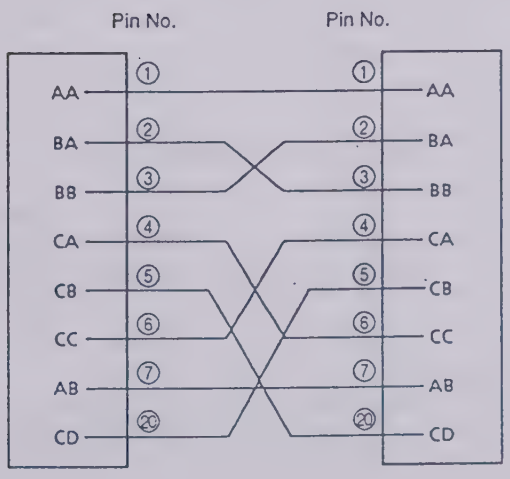
When connecting this instrument to a personal computer, make sure that the handshaking method, data transmission rate and data format selected for the instrument match those selected for the computer. For details, refer to the following pages. Also make sure that the correct interface cable is used.

Connecting the 2531 Digital Power Meter to a Computer Using the RS-232-C Cable



Computer

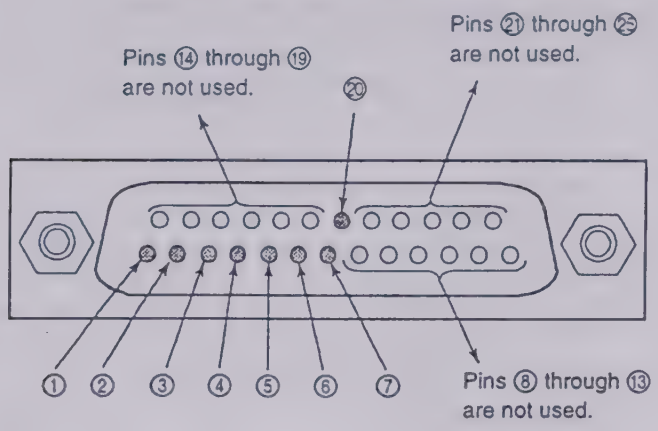
Model 2531



RS-232-C Cable Wiring Diagram

Connector and Signal Names

Numbers in the figure represent Pin Nos.



RS-232-C connector: DBSP-JB25S or equivalent

① AA (GND; Protective Ground)	: Grounded to the case of this instrument.
② BA (TXD; Transmitted Data)	: Data transmitted to personal computer Signal direction : Output
③ BB (BXD; Received Data)	: Data received from personal computer Signal direction : Input
④ CA (RTS; Request to Send)	: Signal used to handshake when receiving data from personal computer Signal direction : Output
⑤ CB (CTS; Clear to Send)	: Signal used to handshake when transmitting data to personal computer Signal direction : Input
⑥ CC (DSR; Data Set Ready)	: Signal used to handshake when transmitting data to personal computer Signal direction : Input
⑦ AB (GND; Signal Ground)	: Ground for signals
⑳ CD (DTR; Data Terminal Ready)	: Signal used to handshake when receiving data from personal computer Signal direction : Output

Note

- Pins ⑧ through ⑲ and ㉑ through ㉕ are not used.

Signal Direction

The figure below shows the direction of the signals used by the RS-232-C interface.

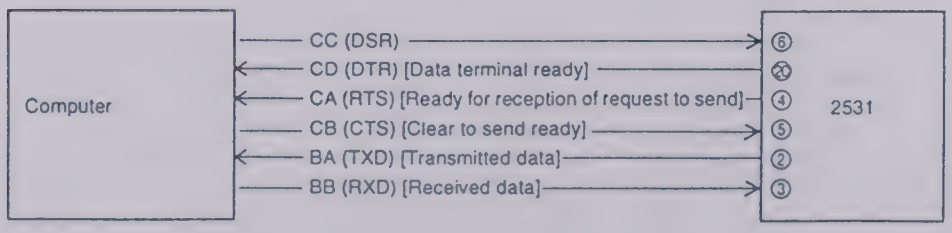


Table of RS-232-C Standard Signals and their JIS and CCITT Abbreviations

Pin No. (25-pin connector)	Abbreviations			Name
	RS-232-C	CCITT	JIS	
①	AA(GND)	101	FG	Protective ground
⑦	AB(GND)	102	SG	Signal ground
②	BA(TXD)	103	SD	Transmitted data
③	BB(RXD)	104	RD	Received data
④	CA(RTS)	105	RS	Request to send
⑤	CB(CTS)	106	CS	Clear to send
⑥	CC(DSR)	107	DR	Data set ready
⑳	CD(DTR)	108/2	ER	Data terminal ready
22	CE(RI)	125	CI	Ring indicator
8	CF(DCD)	109	CD	Data channel received carrier detect
21	CG(-)	110	SQD	Data signal quality detect
23	CH/CI(-)	111	SRS	Data signal rate select
24/15	DA/DB(TXC)	113/114	ST_1/ST_2	Transmitter signal element timing
17	DD(RXC)	115	RT	Receiver signal element timing
14	SBA(-)	118	BSD	Secondary transmitted data
16	SBB(-)	119	BRD	Secondary received data
19	SCA(-)	120	BRS	Secondary request to send
13	SCB(-)	121	BCS	Secondary clear to send
12	SCF(-)	122	BCD	Secondary received carrier detect

Circles indicate pins used for the RS-232-C interface of this instrument.

Handshaking

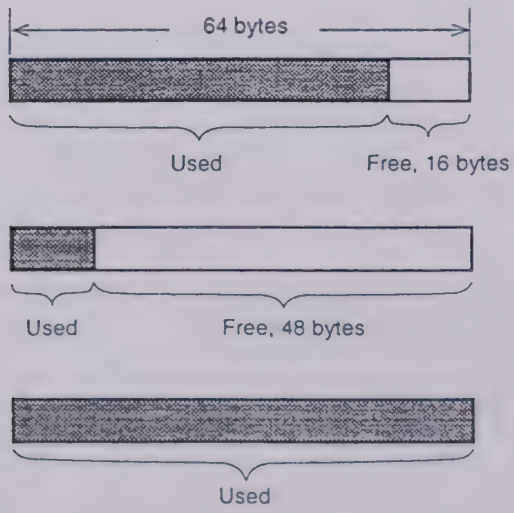
To use an RS-232-C interface to transfer data between this instrument and a computer, it is necessary to use certain procedures by mutual agreement to ensure the proper transfer of data. These procedures are called "handshaking." Various handshaking systems are available depending on the computer to be used; the same handshaking system must be used for both computer and this instrument.
This instrument allows you to choose any handshaking mode from the following eight using the panel keys.

Handshaking System Combinations (A circle indicates that the function is available.)

Mode selection no.	Data sending control (Control method when sending data to computer)				Data receiving control (Control method when receiving data from computer)			
	Software handshake	Hardware handshake			Software handshake	Hardware handshake		
	Sending stops when X-off is received, and sending is resumed when X-on is received.	Sending stops when CB (CTS) is False, and sending is resumed when CB is True.	Sending stops when CC (DSR) is False, and sending is resumed when CC is True.	No handshake	X-off is sent when received data buffer becomes 3/4-full, and X-on is sent when received data buffer becomes 1/4-full.	CD (DTR) is set to False when received data buffer becomes 3/4-full, and is set to True when received data buffer becomes 1/4-full.	CA (RTS) is set to False when received data buffer becomes 3/4-full, and is set to True when received data buffer becomes 1/4-full.	No handshake
0				○				○
1	○				○			
2	○					○		
3	○						○	
4		○				○		
5		○					○	
6			○			○		
7			○				○	

Precautions Regarding Data Receiving Control

When handshaking is used to control received data, data may still be sent from the computer even if the free space in the receive buffer drops below 16 bytes. In this case, after the receive buffer becomes full, the excess data will be lost, whether handshaking is in use or not. Data storage to the buffer will begin again when there is free space in the buffer.



When handshaking is in use, reception of data will stop when the free space in the buffer drops to 16 bytes since data cannot be passed to the main program fast enough to keep up with the transmission.

After reception of data stops, data continues to be passed to the internal program. Reception of data starts again when the free space in the buffer increases to 48 bytes.

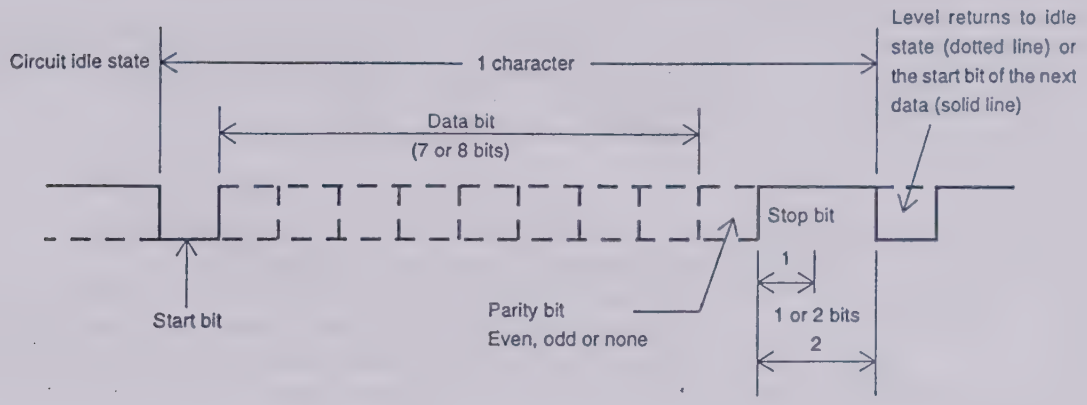
Whether handshaking is in use or not, if the buffer becomes full, any additional data received is no longer stored and is lost.

Data Receiving Control using Handshaking

Data Format

Setting Data Format

The RS-232-C interface of this instrument performs communications using start-stop synchronization. In start-stop synchronization, one character is transmitted at a time. Each character consists of a start bit, data bits, a parity bit, and a stop bit. (Refer to the figure below.)



Data format can be set using the ***LOCAL*** key. For details, refer to the next page.
The table below shows the data format combinations supported.

Data Transmission Format

Preset value	Start bit	Date length	Parity	Stop bit
0	1	8	No	1
1	1	7	Odd	1
2	1	7	Even	1
3	1	7	No	2

Baud Rate

The baud rate can be selected from 75, 150, 300, 600, 1200, 2400, 4800 or 9600.

Data Output

The output data format is identical to that for the GP-IB interface. For details, refer to Section "11.1 Using the GP-IB Interface" (page 11-4).

Setting Normal Mode or Talk-Only Mode

The RS-232-C interface of this instrument has two control modes; normal mode and talk-only mode.
The normal mode is equivalent to addressable mode A of the GP-IB interface function, and enables reception of commands and transmission of data. Measured data is output on reception of the "OD" command.
The talk-only mode is equivalent to the talk-only mode of the GP-IB interface function. Only transmission of measured data is allowed. No commands can be received.
There is no mode that is equivalent to the addressable mode B of the GP-IB interface function with this instrument.

Press the ***LOCAL*** key when the instrument is in remote status. The normal/talk-only mode setting screen will appear on display D. Press the ∧ or ∨ key to select normal or talk-only mode, then press the ***ENTER*** key.

nor→ tonLY →nor...

Setting Handshake Mode, Data Format and Baud Rate

Press the ***LOCAL*** key when the instrument is in remote status.
After normal or talk-only mode has been selected and the ***ENTER*** key has been pressed, the handshake mode, format and baud rate setting screens will be displayed on displays B, C and D respectively. Use the ∧ and ∨ keys to enter each parameter, then press the ***ENTER*** key.

Commands

Commands used for the RS-232-C interface are identical to those used for the GP-IB interface, except for the following commands.

DL/DL?

Sets or inquires about output data terminator type.

Syntax	: DLm <terminator>
	"m" indicates terminator.
	m=0 : CR+LF
	1 : LF
	2 : CR
Inquiry	: DL? <terminator>
Example replay	: DL1

Note

- If a value that is outside the setting range is set, error code "Err 12" is displayed.

The interface message function of the GP-IB interface is assigned to the following commands.

<ESC>S

Equivalent to GP-IB's serial poll function. Status byte is output when the S command is received following reception of the <ESC> code (1BH).

<ESC>R

Equivalent to GP-IB's remote/local control function. The instrument is placed in remote status and panel keys become invalid when the R command is received following reception of the <ESC> code (1BH.) Press the ***LOCAL*** key to exit from remote status.

<ESC>L

Equivalent to GP-IB's remote/local control function. When this instrument is in remote status, the instrument will be placed in local status when the L command is received following reception of the <ESC> code (1BH.)

<ESC>C

Equivalent to GP-IB's device clear function. The communications devices of this instrument are initialized when the C command is received following reception of the <ESC> code (1BH.)

11.3 Before Programming

Basic Programming Format

The following shows the structure of a programming command statement.

Command + Parameter + Terminator

ASCII codes are used.

Example:	DA	2	CR LF
	Command	Parameter	Terminator

Command:

Predefined string of 1 to 3 capital letters

Parameter:

Numeric values or character string (ASCII code)

Terminator:

GP-IB Interface

When this instrument is used as a listener, "CR + LF", "LF" or "EOI" can be used.

When this instrument is used as a talker, the terminator set by the DL command will be used.

RS-232-C

Refer to Section "11.2 Using the RS-232-C Interface" (page 11-16.)

Precautions Regarding Programming

A single line can contain multiple commands. In this case, make sure that command statements (command + parameter) are separated by a semicolon (;).

Note

- A space (or tab) between the command and parameter can be omitted.
- Command statement lines must not exceed 50 characters. Anything after 50 characters will be ignored.

11.4 How to Use the Appendix

This section explains how each command is described in the Appendix.

Inquiry Command

Inquiry commands can easily be identified since "?" is added to the end of the command. Data returned in response to an inquiry command is shown below.

Inquiry command		Returned data
DA?	→	DA1

Numerical Parameter

Floating-point parameters are correct to four decimal places.

Sample Program

A sample program demonstrating the commands is given in the Appendix.

12.1 Storing, Recalling and Initializing Set-up Information

Storing

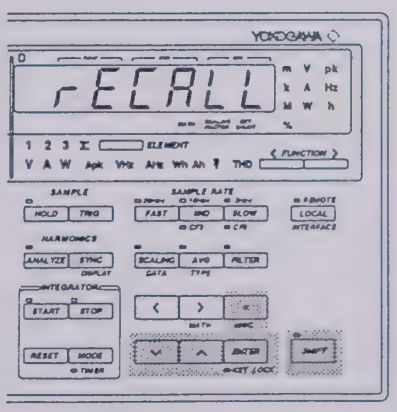
1. Press the *MISC* key (*SHIFT*+ 0).
   Press the ∧ or ∨ key until "StorE" appears on display D.

2. Press the *ENTER* key.
   "FILE 1" will be displayed on display B.

3. Press the ∧ or ∨ key to select the file no. of the built-in memory where the set-up information is to be stored.
   Files from FILE1 to FILE8 are available in the built-in memory.
   The state of the selected file will be displayed on display D.
   If any set-up information already exists in the selected file, the storage date will be displayed. If not, "FrEE" will be displayed.

4. Press the *ENTER* key.
   The current set-up information will be stored into the file selected in step *3*. If any set-up information already exists in the file, the information will be replaced by the current information. Note that the old information will be deleted.

Recalling



1. Press the *MISC* key (*SHIFT*+ 0).
   Press the ∧ or ∨ key until "rECALL" appears on display D.

2. Press the *ENTER* key.
   "FILE 1" will be displayed on display B.

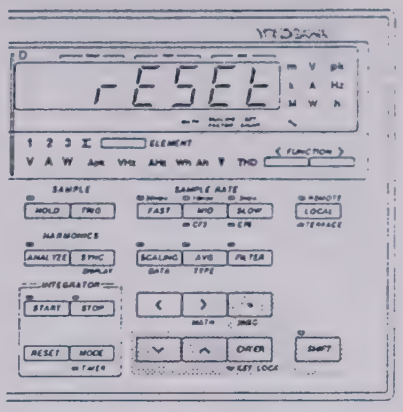
3. Press the ∧ or ∨ key to select the file no. of the built-in memory from which the set-up information is to be recalled.
   The state of the selected file will be displayed on display D.
   If any set-up information already exists in the selected file, the storage date will be displayed. If not, "FrEE" will be displayed.

4. Press the *ENTER* key.
   The set-up information stored in the file selected in step *3* will be recalled. If no set-up information exists in the file, error code "Err30" will be displayed.

Initialization

1. Press the *MISC* key (*SHIFT* + ▫).
   Press the ∧ or ∨ key until "rESEt" appears on display D.

2. Press the *ENTER* key.
   The set-up information will be initialized. All set-up information will be set as shown in Section "2.5 Turning the Power ON or OFF" (page 2-7).



Note

- All measurement data will be lost when initialization is carried out.

12.2 Key Lock Function

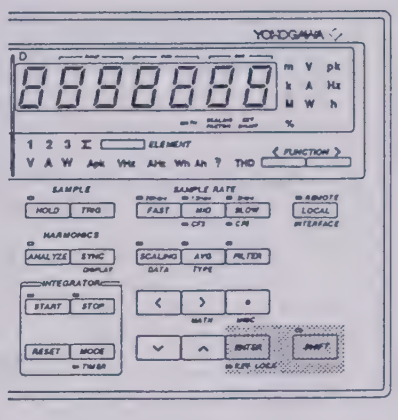
The key lock function is provided to prevent key operations during measurement. Operation of all panel keys except the *POWER* and *SHIFT* keys will be disabled.

Enabling Key Lock Function

Press the *KEY LOCK* key (*SHIFT* + *ENTER*). The KEY LOCK indicator LED will light up.

Disabling Key Lock Function

Press the *KEY LOCK* key (*SHIFT* + *ENTER*) when the KEY LOCK indicator LED is lit. The LED will go out.



12.3 Backup Function for Set-up Information

The instrument is equipped with a lithium battery to provide battery backup for the set-up information in case of power failure.

The following set-up information can be backed up.

Date
Time
Wiring system
Voltage ranges, auto range ON/OFF
Current ranges, auto range ON/OFF
Measurement voltage and current modes for each element
Sample rate
Data hold
Filter
Crest factor
Input element
External shunt scaling value
Scaling ON/OFF
Scaling constant
Averaging ON/OFF
Averaging type
Attenuation constant
Function and element selected for each display
Integration mode
Integration timer preset time
Integration start/stop time
Integrated value
Elapsed time of integration
Phase angle display method
MATH settings
Key lock
Communication output/printer output function
Command group
Communication output mode
Delimiter
Presence/absence of header
Output interval during talk-only
GP-IB address (When equipped with a GP-IB interface)
Handshake mode
Data format
Baud rate
} (When equipped with a RS-232-C interface)
Harmonic analysis ON/OFF
PLL source
Harmonic analysis display format
} When the harmonic analysis function (optional) is incorporated
Print mode
Print interval
Print start/stop time
} When a built-in printer (optional) is incorporated
D/A output function
Rated integration time for D/A outputs
} When D/A output function (optional) is incorporated

13.1 Calibration and Corrective Actions in Cases where Hardware Fails

Calibration

To maintain high measurement accuracy, the instrument should be calibrated every six months.

We recommend that the instrument be properly calibrated by your power meter calibration facility. For details, contact YOKOGAWA or your YOKOGAWA sales representative.

Apparent Hardware Failure - Check these Things First!

If the instrument does not operate properly even if the actions given in the table below are performed, contact YOKOGAWA or your YOKOGAWA sales representative. When contacting them, tell them the ROM version no. displayed on display B on power-up.

Symptom	What to Check	Reference Pages
Nothing is displayed when the power is turned ON.	· Is the power cord securely connected to the power connector of the instrument and the AC outlet? · Is the power voltage within the allowed range? · Has the fuse blown?	2-5,2-6
Displayed data is odd.	· Is there noise? · Are measurement leads connected correctly? · Is the filter off? · Are the ambient temperature and humidity within the allowed range?	2-3,3-1, 3-2,3-4, 4-1
Keys do not function.	· Is the KEY LOCK indicator LED off? · Is the REMOTE indicator LED off?	1-5,11-2, 12-3
Instrument cannot be controlled via GP-IB interface.	· Does the GP-IB address specified in the program match the address set up in the instrument? · Does the interface meet the IEEE Standard 488-1978 electrical and mechanical requirements?	11-1,11-8
Instrument cannot be controlled via RS-232-C interface.	· Are the instrument and controller using the same communications settings?	11-10,11-11

13.2 Error Codes and Corrective Actions

Error Codes for Operation and Measurement

Error Code	Description	Corrective Action	Reference Pages
11	Received command not used by the instrument	Check for error in the command sent.	11-9
12	Parameter value specified is outside allowed range.	Correct the value.	4-8
13	Attempt made to execute a key operation or received a communications command, while integration was running or was interrupted, that cannot be executed or received in such a state.	Check whether integration is in progress or is interrupted.	6-13, 11-9
14	Attempt made to set auto range mode while external shunt range is selected.	It is not possible to set auto range mode while external shunt range is selected.	4-8
15	Attempt made to execute a command or key operation that was protected.	Check whether the command or key operation is correct.	11-9
16	Attempt made to execute a key operation or received a communications command, while harmonic analysis was being performed or was interrupted, that can not be executed or received in such state.	Check whether harmonic analysis is in progress or is interrupted.	—
17	Stop time had passed when *CONT* key was pressed in auto print mode.	Correct the stop time. The stop time must be after the current time.	9-7
18	Data/time cannot be set properly.		—
30	No data stored in the selected set-up information file.	Select a file in which set-up information has been stored.	12-1
41	• Attempt made to start integration while there is an overflow condition. • Attempt made to start integration after integration time has reached timer preset value.	Reset integration.	6-11
42	Attempt made to start integration while integration is in progress.		6-10
43	Measurement stopped due to overflow during integration or due to a power failure.		6-11
44	Attempt made to stop integration even though integration was not in progress.		6-11
45	Attempt made to reset integration even though integration was not in progress or integration mode was not selected.		6-11
46	Attempt made to start integration while measurement of peak overflow was in progress or during an overrange condition.		6-10
47	Attempt made to start integration in continuous integration mode when integration timer preset time was set to "0".	Set a correct preset time.	6-8, 6-9
48	Attempt made to start integration in real time counting integration mode when the stop time had already passed.	Set a correct start/stop time.	6-9, 6-10
50	A/D conversion time-out		—
51	Measurement data overflow occurred. "-oL-" is displayed.		4-11
52	Voltage peak overflow occurred. PEAK OVER indicator LED lights up.		4-12
53	Current peak overflow occurred. PEAK OVER indicator LED lights up.		4-12
54	Power factor exceeded "2" during measurement of power factor.		—

55	"PFErr" was displayed at the end of power factor computation during measurement of phase angle.		4-12 5-5
56	Input level was too low or below measurement range during measurement of frequency. "Err-Lo" is displayed.		4-1, 7-1
57	Measured frequency was above the measurement range. "Err-Hi" is displayed.		7-1
58	Computation overflow occurred. "--oF--" is displayed.		4-11, 8-8
89	Printer's buffer memory was full.	Make sure that the roll chart is set in place.	9-1

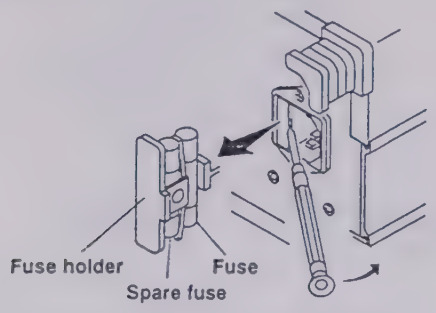
Error Codes Regarding Self Diagnosis

Error Code	Description	Corrective Action
60	Set-up information backup data failure (Set-up information is set to factory default.)	
61	EPROM (input element 1) failure	Service required.
62	EPROM (input element 2) failure	Service required.
63	EPROM (input element 3) failure	Service required.
64	EPROM (D/A board) failure	Service required.
65	A/D converter (input element 1) failure	Service required.
66	A/D converter (input element 2) failure	Service required.
67	A/D converter (input element 3) failure	Service required.
69	Lithium battery voltage drop	Service required.
70	Communications interface board not installed.	Service required.
71	DSP communications failure	Service required.
72	DSP communications failure	Service required.
73	Printer communications failure	Service required.
74	Printer communications failure (ROM failure)	Service required.
75	DSP1 program RAM failure	Service required.
76	DSP2 program RAM failure	Service required.
77	DSP3 program RAM failure	Service required.
79	ROM checksum error	Service required.
80	RAM read/write check error	Service required.
81	DSP1 data RAM failure	Service required.
82	DSP2 data RAM failure	Service required.
83	DSP3 data RAM failure	Service required.
84	DSP1 dual port RAM failure	Service required.
85	DSP2 dual port RAM failure	Service required.
86	DSP3 dual port RAM failure	Service required.
87	Printer RAM failure	Service required.
90	Incorrect board combination	Service required.

13.3 Replacing the Power Supply Fuse

Fuse Position and Replacement Method

The power supply fuse is installed inside the fuse holder located next to the power connector as illustrated below.



Fuse Ratings

Suffix Code	Rating	Part No.
–1 (100 VAC) –2 (115 VAC)	1.25 A time-lag	A1423EF
–5 (200 VAC) –7 (230 VAC)	0.63 A time-lag	A1452EF

WARNING

- **The fuse used must be of the specified rating in order to prevent a fire hazard. Never use a fuse of any other rating, and never short-circuit the fuse holder to bypass the fuse.**
- **Do not operate the Instrument if you have any reason to suspect any defect or problem with the fuse.**

Replacing the Fuse

1. Turn the power switch OFF.
2. Disconnect the power cord from the power connector of the instrument.
3. Place the tip of a flat-blade screwdriver into the slot of the fuse holder, and move the screwdriver in the direction of the arrow to remove the fuse holder.
4. Remove the blown fuse.
5. Insert a new fuse into the holder, then install the holder in place.

Note

- When replacing the fuse for the first time, use the spare fuse supplied in the fuse holder. However, since the spare fuse conforms to the requirements specified when the order was made, and the power supply voltage may have been changed, check whether the spare fuse is appropriate. If the spare fuse is inappropriate, use another fuse that conforms to requirements.

Input

Item	Voltage V	Current A
Input circuit type	Floating input	
	Resistive voltage divider	Shunt input
Rated inputs (range rms)	10/15/30/ 60/100/150/ 300/600 V	1/2/5/10/20/30 A 50/100/200 mV (Ext. shunt input)
Input impedance	Input resistance approx. 2 MΩ (all ranges) Input Capacitance approximate 15 pF in parallel	Shunt: Input resistance approx. 6 mΩ + 0.06 μH (all ranges) External shunt input resistance: Approx. 100 kΩ
Frequency range	DC, 2 Hz-200 kHz	
Instantaneous maximum allowable input for 1s	The peak is 3.5 times the range or 1400 V, whichever is less.	The peak is 10 times the range or 60 A, whichever is less Ext. Shunt input: Peak value is 20 times the range or less
Continuous maximum allowable input	The peak is 1000 V or the RMS value is twice the range, whichever is less.	The peak is 5 times the range or the RMS value is twice the range, whichever is less with a maximum of 35 A rms. Ext. Shunt input: Peak value is 10 times the range or less
Maximum common mode voltage	600 Vrms	600 Vrms
Common mode rejection ratio at 600 Vrms between input terminals and case (at 50/60 Hz)	better than –80 dB (0.01% of range) (Input closed)	better than –80 dB (0.01% of range) (Input open)
Input terminals	Binding posts	Large binding posts Ext. shunt input: 4 pin round connector
Filter	Low pass filter fc fixed at 500 Hz can be switched ON/OFF	
A/D conversion	Simultaneous sampling of Voltage and Current inputs Resolution: 16 Bits Maximum conversion rate: approx. 104 kHz	
Peak Over range detection	Approximate at 3.5 times the input range the alarm LED will light. (At crest factor set to 6, approx. 700% of the range)	
Range switching	Manual, automatic and external via GP-IB/RS-232-C Range can be selected all elements simultaneous, or separate for each element	
Auto range switching	Range up: When the peak value exceeds 3.5 times of the rated range or the measured value exceeds 110% of the rated range (When crest factor is set to 3) Range down: When the measured value becomes less than 30% of the rated range	
Measurement mode	The mode can be set for each element separately RMS: RMS measurement MEAN: Rectified Mean Calibrated to a RMS sine wave measurement DC: Mean value measurement (DC component)	

Display functions

Display type: 7 segment LED
Number of displays: 4

DISPLAY	Displayed Value	Maximum Reading
A	V, A, W (each element)	V, A, W: 30000
B	V, A, W (each element)	Wh, Ah: 300000
C	V, A, W, var, PF, deg, Vpk (each element)	Hz: 199999
D	V, A, W, Apk, THD*, VHz, AHz, Wh Ah (each element), η (Efficiency)	

*Total Harmonic Distortion Analysis (Optional Feature) added

Unit : m, k, M, V, A, W, VA, var, pk, Hz, h, deg, %
Display Update Rate : 0.25 s (FAST), 0.5 s (MID) 2.0 s (SLOW) selectable
Response Time : Within two update cycles
(Time for displayed value to settle within accuracy specifications of final value after step change from 0% to 100% or 100% to 0% of range, FILTER OFF)

Display Scaling Function

Significant digits : Selected automatically according to significant digits in the Voltage and Current Ranges
Reassign Ratio : 0.0001 - 10000
Settable parameters : Display A : Not Used
Display B : PT ratio
Display C : CT ratio
Display D : Power Scaling Factor

Display Averaging Function

Algorithm : Two algorithms can be selected
- Exponential averaging
- Moving averaging

For Exponential averaging the Attenuation constant can be selected and for the Moving averaging the number of averages can be set to 8, 16, 32, 64, 128, 256.

MATH Function

Algorithm : Display D, when selecting the efficiency function *h*, will show the efficiency. In addition it is possible to show the result of Display A, +, –, / or x Display B on Display D.

Frequency Measurement

Input : V1, V2, V3, A1, A2, A3
Operating principle : Reciprocal counting method
Frequency ranges : The range depends on the selected Display Update Interval (Auto Range)
FAST : 2k/20k/200k/1000 kHz
MID : 200/2k/20k/200k/500 kHz
SLOW : 20/200/2k/20k/100 kHz
Maximum reading : 199999
Minimum reading : FAST : 18.00 Hz
MID : 9.000 Hz
SLOW : 1.8000 Hz
Accuracy : ±0.05% of rdg
- Minimum input is ±30% of range
- Minimum Input frequency is 20% of frequency range when Crest Factor is set to 3
- When FILTER is switched ON, the input frequency must be less than 200 Hz to obtain the specification accuracy.

Measurement Functions Accuracy

Item	Voltage/Current	Power
Method	Digital Multiplication System	
Crest Factor	Selectable to 3 or 6	
Display Accuracy (Conditions:) Temperature: 23°C±5°C Humidity: 30% to 75% R. H. Supply voltage: specified supply voltage, ±5% Input Waveform: Sine Wave Common Mode Voltage: 0 V Filter: OFF Averaging: OFF Crest Factor: set to 3 At Power Factor: cosφ = 1 Within 6 months after calibration YOKOGAWA STANDARD	DC ±(0.05% of rdg + 0.1% of mg) 30 Hz ≦ f ≦ 1 kHz ±(0.03% of rdg + 0.05% of mg) 10 Hz ≦ f < 30 Hz, 1 kHz < f ≦ 10 kHz ±(0.1% of rdg + 0.2% of mg) 2 Hz ≦ f < 10 Hz, 10 kHz < f ≦ 50 kHz ±(0.5% of rdg + 0.5% of mg) 50 kHz < f ≦ 100 kHz ±(1% of rdg + 1.5% of mg) 100 kHz < f ≦ 200 kHz ±(3% of rdg + 3% of mg) Update interval condition f ≧ 10 Hz, MID f ≧ 2 Hz, SLOW	DC ±(0.1% of rdg + 0.15% of mg) 30 Hz ≦ f ≦ 1 kHz ±(0.05% of rdg + 0.05% of mg) 10 Hz ≦ f < 30 Hz, 1 kHz < f ≦ 10 kHz ±(0.2% of rdg + 0.5% of mg) 2 Hz ≦ f < 10 Hz, 10 kHz < f ≦ 50 kHz ±(1.0% of rdg + 1.5% of mg) 50 kHz < f ≦ 100 kHz ±(2.5% of rdg + 2.5% of mg) 100 kHz < f ≦ 200 kHz ±(10% of rdg + 6% of mg) Update interval condition f ≧ 10 Hz, MID f ≧ 2 Hz, SLOW
Effect of Power Factor	———	COSφ = 0 45 Hz to 440 Hz: ±0.15% of mg
Effective Input range	With input range at 10% to 110% the above specified accuracy is valid. With input at 110% to 130% the above specified reading accuracy times 1.5. The display reading operates until 140% of the input range.	
Accuracy at Crest Factor set to 6	The specified accuracy at Crest Factor set to 3 times 1.5.	
Temperature coefficient 5 to 18°C, 28 to 40°C	±0.02% of range/°C	
Display update rate	0.25 s (FAST), 0.5 s (MID), 2.0 s (SLOW)	
Influence of Filter	50/60 Hz, Displayed accuracy ±1% of mg	50/60 Hz, COSφ = 1 Displayed accuracy ±2% of mg

Computing Functions

		Active Power (W)	Apparent Power (VA)	Reactive power (var)	Power Factor (PF)	Phase Angle (deg)
Computation	1-phase 2-wire	W	VA = V × A	$\sqrt{(VA)^2 - W^2}$	$\frac{W}{VA}$	$\cos^{-1}(\frac{W}{VA})$
	1-phase 3-wire	W_i i = 1, 3 $\Sigma W = W_1 + W_3$	$VA_i = V_i \times A_i$ i = 1, 3 $\Sigma VA = VA_1 + VA_3$	$var_i = \sqrt{(VA_i)^2 - W_i^2}$ i = 1, 3 $\Sigma var = var_1 + var_3$	$PF_i = \frac{W_i}{VA_i}$ i = 1, 3 $\Sigma PF = \frac{\Sigma W}{\Sigma VA}$	$\varphi_i = \cos^{-1}(\frac{W_i}{VA_i})$ i = 1, 3 $\Sigma\delta = \cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
	3 phase 3-wire (two power meter method)	W_i i = 1, 3 $\Sigma W = W_1 + W_3$	$VA_i = V_i \times A_i$ i = 1, 3 $\Sigma VA = \frac{\sqrt{2}}{3}(VA_1 + VA_3)$	$var_i = \sqrt{(VA_i)^2 - W_i^2}$ i = 1, 3 $\Sigma var = var_1 + var_3$	$PF_i = \frac{W_i}{VA_i}$ i = 1, 3 $\Sigma PF = \frac{\Sigma W}{\Sigma VA}$	$\varphi_i = \cos^{-1}(\frac{W_i}{VA_i})$ i = 1, 3 $\Sigma\delta = \cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
	3 phase 3-wire (three power meter method)	W_i i = 1, 2, 3 $\Sigma W = W_1 + W_3$	$VA_i = V_i \times A_i$ i = 1, 2, 3 $\Sigma VA = \frac{\sqrt{3}}{3}(VA_1 + VA_2 + VA_3)$	$var_i = \sqrt{(VA_i)^2 - W_i^2}$ i = 1, 2, 3 $\Sigma var = var_1 + var_3$	$PF_i = \frac{W_i}{VA_i}$ i = 1, 2, 3 $\Sigma PF = \frac{\Sigma W}{\Sigma VA}$	$\varphi_i = \cos^{-1}(\frac{W_i}{VA_i})$ i = 1, 2, 3 $\Sigma\delta = \cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
	3 phase 4-wire	W_i i = 1, 2, 3 $\Sigma W = W_1 + W_2 + W_3$	$VA_i = V_i \times A_i$ i = 1, 2, 3 $\Sigma VA = VA_1 + VA_2 + VA_3$	$var_i = \sqrt{(VA_i)^2 - W_i^2}$ i = 1, 2, 3 $\Sigma var = var_1 + var_2 + var_3$	$PF_i = \frac{W_i}{VA_i}$ i = 1, 2, 3 $\Sigma PF = \frac{\Sigma W}{\Sigma VA}$	$\varphi_i = \cos^{-1}(\frac{W_i}{VA_i})$ i = 1, 2, 3 $\Sigma\delta = \cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
Computating Range		Depends on selected V and A range	Depends on selected V and A range	Depends on selected V and A range (var≧0)	−1–0–1	−180–0–180 or 0–360
Maximum Display or Display Resolution		30000	30000	30000	±1.0000	0.01
Commuting Accuracy		—	±0.001% of VA range	±0.001% of VA range	±0.0001	Calculated from the Power Factor, with an additional error of ±0.005°

Note 1: The apparent power (VA), reactive power (var), power factor (PF), and phase angle (deg) measurement in this instrument are computed digitally from the voltage, current and active power. If the input is non-sinusoidal, the measured values may differ from those obtained with instruments employing different measurement principles.

Note 2: When the Current or Voltage value is less than 0.3% of range, the VA and var will be displayed 0, and PF/deg will be displayed as Error.

Note 3: The Lead and Lag are displayed for V and A input at 30% or more. The detected Lead/Lag accuracy is ±5 degree over the frequency range 20 Hz to 10 kHz.

Note 4: When the phase angle display shows an angle smaller than 5 degree at 0° and 180°, the accuracy is not specified.

Note 5: If the scaling values set for each element differ from each other in the case of Σ computation, the number of display digits will be limited so that Σ value does not exceed 30000 (crest factor: 3) or 10000 (crest factor: 6) when the rated value is input to each corresponding element. A voltage of 5 V (full scale) will be output from the D/A converter as the Σ value obtained when the rated value is input to each corresponding element.

Integrator Function (Wh, Ah)

Maximum display : 300000
According to the displayed value, the resolution will be changed.
Frequency range : DC to 50 kHz
Modes : Standard Integration Mode (timer mode)
Continuous Integration Mode (repeat mode)
Manual Integration Mode
Timer : When the timer is set, Integration will be stopped automatically.
Setting range : 000 h: 00min to 999 h: 59 min
(000 h: 00min will be shown when manual integration mode is selected.)
Display : Display A shows : Elapsed time
Display B/C shows : Watt
Display D shows : Watt, Wh, Ah, Hz
Output : For the output of the printer, communication and D/A, fourteen free selectable items from above items can be set. (except for elapsed time)
Count Overflow : If integration count overflows the maximum displayable value, integration stops and the elapsed time is held on the display.
Real Time Counting : The integration time can be controlled REAL TIME.
Accuracy : ±(display accuracy + 0.05% of rdg)
Timer accuracy : ±0.005%
Remote Control : Start, stop and reset can be remotely controlled by external contact signals.

Communication

Communication Specifications (GP-IB & RS-232-C)
GP-IB
Electrical specifications : IEEE Std 488-1978
Mechanical specifications : IEEE Std 488-1978
Interface functions : SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT1, C0
RS-232-C
Transmission mode : Start Stop Synchronization
Baud Rate : 75, 150, 300, 600, 1200, 2400, 4800, 9600 bps

Printer (Optional)

Printed Parameters : Normal Mode : 14 free selectable numerical items from each channel identical to the communications parameters
THD Mode : Numerical print out of V, A, W, PF, deg
Bar Graph print out of V, A, W, PF, deg
Printing type : Thermal line dot printing

D/A Output (Optional)

Number of output channels : 14 simultaneous
Resolution : 12 bit
Output Voltage : ±5V DC at rated value or range (maximum, approx. 7.5 V DC, maximum output current approx. 1 mA)
Accuracy : Display accuracy ±0.2% of range
Temperature coefficient : ±0.05% of F. S. / °C
Update rate : Identical to display update interval

General Specifications

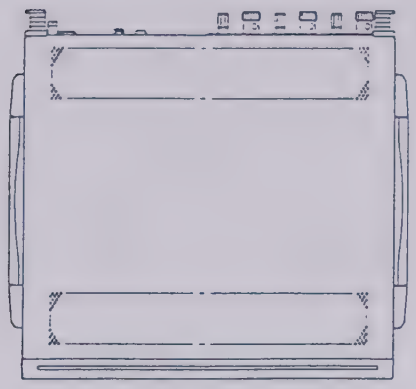
External Control and output signals
Input/output signals : EXT-HOLD, EXT-TRIG, EXT-START, EXT-STOP, EXT-RESET, EXT-PRINT, INTEG-BUSY
Input Level : TTL negative pulse
D/A output (optional) : 14 items fixed as default value and 14 free selectable items at selectable mode.
Printer output (optional) : 14 items fixed as default value and 14 free selectable items at selectable mode.
However, common setting with items for communication output.
Communication output : 14 items fixed as default value and 14 free selectable items at selectable mode.
However, common setting with items for printing.
Warm up time : Approx. 30 min.
Ambient temperature and humidity range : 5 to 40°C, 20 to 80% R. H. (no condensation)
Storage temperature : −25 to 60°C (no condensation)
Insulation resistance : between voltage input terminals and case
between current input terminals and output terminals
between voltage input terminals and current input terminals
between voltage input terminals of each element
between current input terminals of each element
between voltage input terminals and power plug
between current input terminals and power plug
between case and power plug
Above: 50 MΩ or more at DC 500 V
Withstand Voltage : between voltage input terminals and case
between current input terminals and output terminals
between voltage input terminals and current input terminals
between voltage input terminals of each element
between current input terminals of each element
between voltage input terminals and power plug
between current input terminals and power plug
Above: AC 2200 V for 1 minute at 50/60 Hz
between case and power plug
1500 V for 1 minute at 50/60 Hz
Power supply : Setting / Allowable Voltage range / Frequency

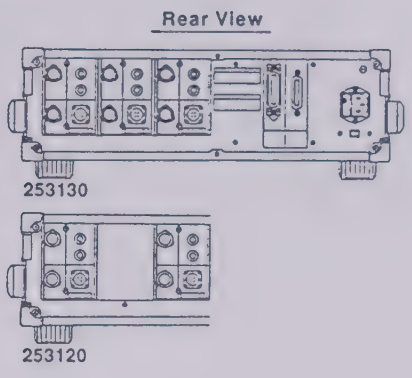
Setting	Allowable Voltage range	Frequency
100 V	90 to 110 V	48 to 63 Hz
115 V	100 to 132 V	48 to 63 Hz
200 V	180 to 220 V	48 to 63 Hz
230 V	198 to 264 V	48 to 63 Hz

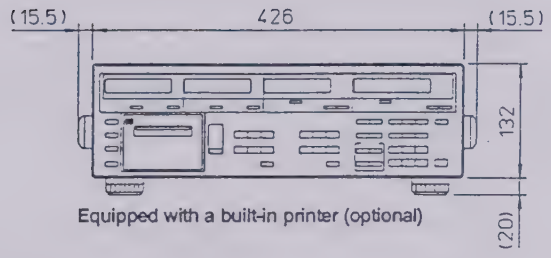
Vibration test condition : Sweep test-Frequency 8 to 150 Hz sweep, all 3 directions for 1 minute
Endurance test-Frequency 16.7 Hz, all 3 directions amplitude 4 mm for 2 h
Impact condition : Impact test: Acceleration 490 m/s², all 3 directions
Free fall test-Height 100 mm, 1 time for each 4 sides
Power supply : 120 VA Max
Internal clock accuracy : ±30 sec. in a month
External dimensions : Approx. 132 (H) × 426 (W) × 429 (D) mm
Approx. 5.2 (H) × 16.8 (W) × 16.9 (D) inches
Weight : Model 253120 Approx. 13 kg (29 lbs)
Model 253130 Approx. 14 kg (31 lbs)
Accessories : Power code : UL/VDE/SAA or BS standard × 1 pcs.
Fuse : 250 V/1.25 A (for 100/115 V) or 0.63 A (for 200/230 V) × 2 pcs.
(1 pc. is attached to the instrument)
Remote control : Connector A1005JD × 1
External shunt connector : B9293LQ (1 pc. for 1 element)

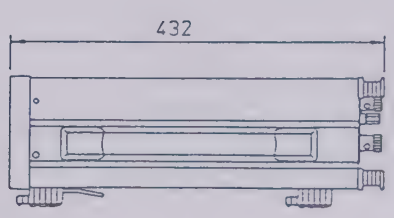
External Dimensions

(mm)

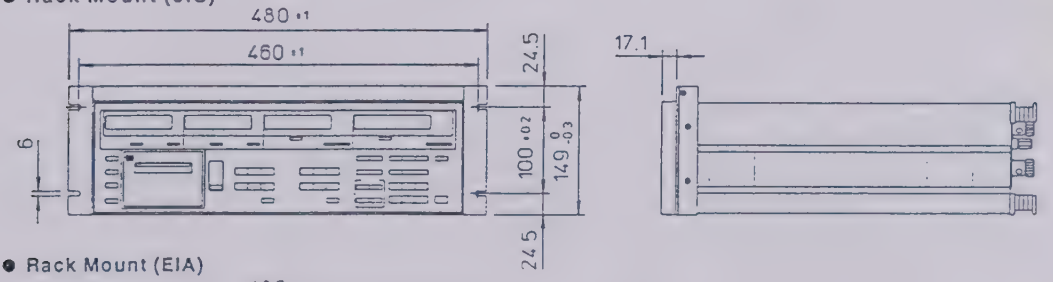




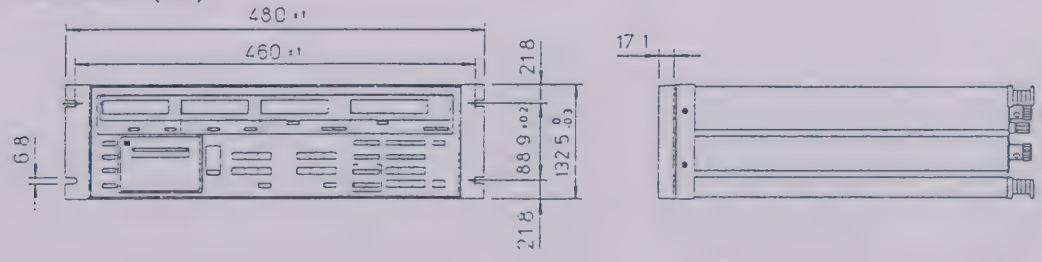




● Rack Mount (JIS)



● Rack Mount (EIA)



Unless otherwise specified, tolerance is ±3%. (However, tolerance is ±0.3 mm when below 10 mm.)

AA/AA?

Sets auto or manual range mode for the current ranges/inquires about the current setting.

Syntax: AA m1,m2 <terminator>
"m1" indicates input element.
m1=0 : All elements
1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"m2" indicates whether range mode is auto or manual.
m2=0 : Manual range
1 : Auto range

Inquiry: AAm1? <terminator>
Response example: AA1,0
Description:
- Parameter error 12 will occur if either "m1" or "m2" is set to an illegal value.
- Auto range is not allowed while integration is in progress: execution error 13 will occur.
- If the range is changed during auto range mode, manual range mode will be validated instead of auto range mode.
- If integration is started during auto range mode, auto range mode will be invalidated.
- Auto range mode is not allowed if the external shunt range is selected: execution error 14 will occur.
- "m1" of AAm1? indicates the input element selected. If "0" is set, error 12 will occur.

AB

Causes the printer to stop printing.

Syntax: AB <terminator>
Description:
- This command is not valid unless printing is in progress.

AC/AC?

Sets attenuation constant/inquires about the current setting. The constant set is used as the attenuation constant for exponential averaging, or as the number of data for moving averaging.

Syntax: AC m <terminator>
"m" indicates attenuation constant.
m=1 : 8
2 : 16
3 : 32
4 : 64
5 : 128
8 : 256

Inquiry: AC? <terminator>
Response example: AC1
Description:
- Parameter error 12 will occur if a value outside the allowed range is set.

AG/AG?

Determines whether or not averaging should be performed/inquires about the current setting.

Syntax: AG m <terminator>
"m" indicates whether averaging is ON or OFF.
m=0 : OFF.
1 : ON.

Inquiry: AG? <terminator>
Response example: AG1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

AT/AT?

Sets averaging type (exponential or moving)/inquires about the current setting.

Syntax: AM m <terminator>
"m" indicates averaging type
m=0 : Exponential averaging
1 : Moving averaging

Inquiry: AM? <terminator>
Response example: AM1
Description:
- Averaging cannot be turned ON while integration is in progress,: error 12 will occur.
- Parameter error 12 will occur if "m" is set to an illegal value.

AV/AV?

Sets auto or manual range mode for the voltage ranges/inquires about the current setting.

Syntax: AV m1,m2 <terminator>
"m1" indicates input element.
m1=0 : All elements
1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"m2" indicates whether range mode is auto or manual.
m2=0 : Manual range
1 : Auto range

Inquiry: AVm1? <terminator>
Response example: AV1,0
Description:
- Auto range is not allowed while integration is in progress: execution error 13 will occur.
- If the range is changed during auto range mode, manual range mode will be validated instead of auto range mode.
- If integration is started during auto range mode, auto range mode will be invalidated.
- "m1" of AVm1? indicates the input element selected. If "0" is set for m1, error 12 will occur.

CF/CF?

Sets crest factor/inquires about the current setting.

Syntax: CF m <terminator>
"m" indicates crest factor.
m=3 : 3
6 : 6

Inquiry: CF? <terminator>
Response example: CF3
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Changing of the crest factor is not allowed while integration is in progress: execution error 13 will occur.

CM/CM?

Selects 2531 scaling value simultaneously or individual setting command group, or 2533E setting command group for command data which come after this command/inquires the current setting.

Syntax: CM m <terminator>
"m" indicates command group used.
m=0 : 2531 command/output format group
(Scaling value simultaneous setting command group)

1 : 2531 command/output format group
(Scaling value individual setting command group)
2 : 2533E command/output format group

Inquiry: CM? <terminator>
Response example: CM1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- 2531 output format is the same whether "m" is set to 0 or 1.
- With the 2531 with ROM version of below 2.01, error 11 will occur if an attempt is made to set the "CM" command.

DA/DA?

Sets the function for display A/inquires about the current setting.

Syntax: DA m <terminator>
"m" indicates one of the following functions.
m=1 : Voltage
2 : Current
3 : Power

Inquiry: DA? <terminator>
Response example: DA1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Elapsed time of integration is displayed on display A while integrated value (Wh or Ah) is displayed on display D. Changing of the function is not allowed; execution error 13 will occur.

DB/DB?

Sets the function for display B/inquires about the current setting.

Syntax: DB m <terminator>
"m" indicates one of the following functions.
m=1 : Voltage
2 : Current
3 : Power

Inquiry: DB? <terminator>
Response example: DB1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

DC/DC?

Sets the function for display C/inquires about the current setting.

Syntax: DC m <terminator>
"m" indicates one of the following functions.
m=1 : Voltage (V)
2 : Current (A)
3 : Power (W)
4 : Reactive power (var)
5 : Apparent power (VA)
6 : Power factor (PF)
11 : Phase angle (deg)
12 : Voltage peak (V peak)

Inquiry: DC? <terminator>
Response example: DC1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

DD/DD?

Sets the function for display D/inquires about the current setting.

Syntax: DD m <terminator>
"m" indicates one of the following functions.
m=1 : Voltage (V)
2 : Current (A)
3 : Power (W)
7 : Input voltage frequency (V Hz)
8 : Input current frequency (A Hz)
9 : Watt-hour (Wh)
10 : Ampere-hour (Ah)
13 : Current peak (A peak)
14 : Efficiency or computed result

Inquiry: DD? <terminator>
Response example: DD1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Elapsed time of integration is displayed on display A if integrated value is selected for display D.

DG/DG?

Sets the phase angle display method/inquires about the current setting.

Syntax: DG m <terminator>
"m" indicates display method.
m=0 : 180?
1 : 360?

Inquiry: DG? <terminator>
Response example: DG0
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

DL/DL?

Sets the terminator for communication output data/inquires about the current setting.

Syntax: DL m <terminator>
"m" indicates terminator.

	GP-IB	RS-232-C
m=0 :	CR LF EOI	CR LF
1 :	LF	LF
2 :	EIO	CR

Inquiry: DL? <terminator>
Response example: DL0
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

DT/DT?

Sets the date for the internal clock of the 2531/inquires about the current setting.

Syntax: DT m1,m2,m3 <terminator>
"m1" indicates year, and must be set within the following range.
1993 ≦ m1 ≦ 2092
"m2" indicates month, and must be set within the following range.
1 ≦ m2 ≦ 12
"m3" indicates day, and must be set within the following range.
1 ≦ m3 ≦ 30, 31, 28 or 29

Inquiry: DT? <terminator>
Response example: DT1993/11/8
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

EA/EA?

Sets the element for display A/inquires about the current setting.

Syntax: EA m <terminator>
"m" indicates element.
m=1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
4 : Σ

Inquiry: EA? <terminator>
Response example: EA1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

- Elapsed time of integration is displayed on display A while integrated value (Wh or Ah) is displayed on display D. Changing of the element is not allowed: execution error 13 will occur.

EB/EB? Sets the element for display B/inquires about the current setting.

Syntax: EB m <terminator>
"m" indicates element.
m=1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
4 : Σ

Inquiry: EB? <terminator>
Response example: EB1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

EC/EC? Sets the element for display C/inquires about the current setting.

Syntax: EC m <terminator>
"m" indicates element.
m=1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
4 : Σ

Inquiry: EC? <terminator>
Response example: EC1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

ED/ED? Sets the element for display D/inquires about the current setting.

Syntax: ED m <terminator>
"m" indicates element.
m=1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
4 : Σ

Inquiry: ED? <terminator>
Response example: ED1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Changing of the element for display D is not allowed while efficiency is displayed on display D: execution error 15 will occur.

E,ST.<interface message GET> Generates a trigger.

Syntax: E <terminator>
ST <terminator>
<interface message GET>
Description:
- This command is valid only during sample hold mode.

FD/FD? Feeds print paper.

Syntax: FD m <terminator>
"m" indicates number of lines to be feed, and must be within the following range.
$1 \leq m \leq 20$

Inquiry: FD? <terminator>
Response example: FD1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- When paper feed is carried out using a key operation, one line is fed each time the key operation is performed.

FL/FL? Determines whether or not filter is used/inquires about the current setting.

Syntax: FL m <terminator>
"m" indicates whether filter is ON or OFF.
m=0 : ON
1 : OFF

Inquiry: FL? <terminator>
Response example: FL1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Filter cannot be switched ON or OFF while integration is in progress: error 13 will occur.

HD/HD? Determines whether or not output data should be updated/inquires about the current setting.

Syntax: HD m <terminator>
"m" indicates the sampling mode.
m=0 : Updates the data at each sampling rate.
1 : Hold

Inquiry: HD? <terminator>
Response example: HD0
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

H/H? Determines whether or not to add a head to measured data output via communication/inquires about the current setting.

Syntax: H m <terminator>
"m" indicates whether a header is added or not.
m=0 : No header added
1 : Header added

Inquiry: H? <terminal>
Response example: H0
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

IC/IC? Sets the integration mode/inquires about the current setting.

Syntax: IC m <terminator>
"m" indicates one of the following integration modes.
m=0 : Normal integration mode
1 : Continuous integration mode
2 : Real time counting standard integration mode
3 : Real time counting continuous integration mode

Inquiry: IC? <terminator>
Response example: IC1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Changing of the integration mode is not allowed while integration is in progress: execution error 47 will occur.
- If real time counting integration mode (normal or continuous) is used, set both the start time and stop time to times after the current time. Executing the IS command after both the start time and stop time have been set will place the instrument in standby state.
- If continuous integration mode is selected, make sure that the timer preset time is set to a value larger than "0".
- If normal integration mode is selected, set the timer preset time to any desired value.

IM/IM?

Specifies which causes will be allowed to generate a status byte/inquires about the current setting.

Syntax: IM m <terminator>
"m" is assigned as follows (0 ≤ m ≤ 15).
m=1 : Computation end
2 : Integration end
4 : Syntax error
8 : OVER

Inquiry: IM? <terminator>
Response example: IM15
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- If more than one of these causes is to be allowed, set "m" to the sum of their individual "m" values. For instance, if all causes are to be allowed, set "m" to 15 (=1+2+4+8).

IP

Stops integration.

Syntax: IP <terminator>
Description:
- If an attempt is made to stop integration when integration has already been interrupted (stopped), execution error 44 will occur.

IR

Resets integration.

Syntax: IR <terminator>
Description:
- If an attempt is made to reset integration while integration is in progress, execution error 45 will occur.

IS

Starts integration.

Syntax: IS <terminator>
Description:
- If an attempt is made to start integration when integration is already in progress, execution error 42 will occur.
- If a voltage or current peak overflow, or overrange takes place when an attempt is made to start integration, execution error 46 will occur, and integration will not be started.

IT/IT?

Sets the integration start time and stop time/inquires about the current settings.

Syntax: IT m1/m2/m3/m4/m5/m6,m7/m8/m9/m10/m11/m12 <terminator>
"m1" indicates start year, and must be set within the following range.
1993 ≤ m1 ≤ 2092
"m2" indicates start month, and must be set within the following range.
1 ≤ m2 ≤ 12
"m3" indicates start day, and must be set within the following range.
1 ≤ m3 ≤ 30, 31, 28 or 29
"m4" indicates start hour, and must be set within the following range.
0 ≤ m4 ≤ 23
"m5" indicates start minute, and must be set within the following range.
0 ≤ m5 ≤ 59
"m6" indicates start second, and must be set within the following range.
0 ≤ m6 ≤ 59
"m7" indicates stop year, and must be set within the following range.
1993 ≤ m7 ≤ 2092
"m8" indicates stop month, and must be set within the following range.
1 ≤ m8 ≤ 12
"m9" indicates stop day, and must be set within the following range.
1 ≤ m9 ≤ 30, 31, 28 or 29
"m10" indicates stop hour, and must be set within the following range.
0 ≤ m10 ≤ 23
"m11" indicates stop minute, and must be set within the following range.
0 ≤ m11 ≤ 59
"m12" indicates stop second, and must be set within the following range.
0 ≤ m12 ≤ 59

Inquiry: IT? <terminator>
Response example: IT2002/1/1/0/0/0,2001/1/3/0/0/0
Description:
- Parameter error 12 will occur if an illegal value is set.
- If the stop time is before the start time, parameter error 12 will occur.

KV/KV?, KA/KA?, KW/KW?

Sets the scaling constant/inquires about the current setting.
KV is used for voltage measurement, KA for current measurement, and KW for power measurement.

Syntax: When CM0 is set:
KVn <terminator>
KAn <terminator>
KWn <terminator>
When CM1 is set:
KVm,n <terminator>
KAm,n <terminator>
KWm,n <terminator>
"m" indicates element.
m=0 : All elements (Setting not allowed during inquiry)
1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"n" indicates scaling value.
0.0001 ≤ n ≤ 10000

Inquiry: When CM0 is set:
KV? <terminator>
KA? <terminator>
KW? <terminator>
When CM1 is set:
KV1? <terminator>
KA2? <terminator>
KW3? <terminator>
Response example: When CM0 is set:
KV1.0000
KA1.0000
KW1.0000
When CM1 is set:
KV1,1.0000
KA2,1.0000
KW3,1.0000
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- "n" must be floating-point or integer.
- Error 12 will occur when an inquiry is made if the scaling values set for each element by CM0 differ from each other.

MA/MA?

Sets the measurement mode for current/inquires about the current setting.

Syntax: MA m1,m2 <terminator>
"m1" indicates input element.
m1=0 : All elements -

1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"m2" indicates measurement mode.
m2=0 : RMS
1 : MEAN
2 : DC

Inquiry: MAm1? <terminator>
Response example: MA1,0
Description:
- Parameter error 12 will occur if "m1" or "m2" is set to an illegal value.
- Changing of the measurement mode is not allowed while integration is in progress; execution error 13 will occur.
- "m1" of MAm1? indicates the input element selected. If "0" is set, error 12 will occur.

MT/MT?

Sets the MATH equation/inquires about the current setting. If an equation other than that for efficiency is selected, the equation will be executed and the result displayed on display D, even if efficiency has already been displayed on display D.

Syntax: MT m <terminator>
"m" indicates one of the following equations.
m=0 : Efficiency
1 : Crest factor of voltage input waveform applied to input element 1
2 : Crest factor of voltage input waveform applied to input element 2
3 : Crest factor of voltage input waveform applied to input element 3
4 : Crest factor of current input waveform applied to input element 1
5 : Crest factor of current input waveform applied to input element 2
6 : Crest factor of current input waveform applied to input element 3
7 : Display A + Display B
8 : Display A − Display B
9 : Display A × Display B
10 : Display A / Display B

Inquiry: MT? <terminator>
Response example: MT1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

MV/MV?

Sets the measurement mode for voltage/inquires about the current setting.

Syntax: MV m1,m2 <terminator>
"m1" indicates input element.
m1=0 : All elements
1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"m2" indicates measurement mode.
m2=0 : RMS
1 : MEAN
2 : DC

Inquiry: MVm1? <terminator>
Response example: MV1,0
Description:
- Parameter error 12 will occur if "m1" or "m2" is set to an illegal value.
- "m1" of MVm1? indicates the input element selected. If "0" is set, error 12 will occur.
- Changing of the measurement mode is not allowed while integration is in progress; execution error 13 will occur.

OA/OA?

Sets D/A output items/inquires about the current settings.
Up to 14 measured data can be selected and output as analog signal from the D/A converter.

Syntax: OA m1,m2,m3 <terminator>
"m1" indicates D/A output channel, and must be set within the following range.
1 ≤ m1 ≤ 14
"m2" indicates output item no.
m2=0 : No output
1 : Voltage (V)
2 : Current (A)
3 : Power (W)
4 : Reactive power (var)
5 : Apparent power (VA)
6 : Power factor (PF)
7 : Input voltage frequency (V Hz)
8 : Input current frequency (A Hz)
9 : Watt-hour (Wh)
10 : Ampere-hour (Ah)
11 : Phase angle (deg)
12 : Voltage peak (V peak)
13 : Current peak (A peak)
14 : Efficiency
"m3" indicates element, and must be set within the following range.
1 ≤ m3 ≤ 4

Inquiry: OA1? <terminator>
Response example: OA1,3,2
Description:
- Parameter error 12 will occur if any of "m1", "m2" and "m3" is set to an illegal value.
- If "14" (efficiency) is selected for "m2", no D/A output is produced if equation for efficiency has bee selected by MT/MT? command.

OAD/OAD?

Initializes D/A output items/inquires about the current settings. Two sets of default settings are available: one is for normal measurement and the other is for integration. The same initialization can also be performed using a key operation.

Syntax: OAD m <terminator>
"m" indicates default no.
m=2 : Select mode
0 : Default for normal measurement
1 : Default for integration

Inquiry: OAD? <terminator>
Response example: OAD1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Select mode (OAD2) is validated when the OA command is executed if "m" has been set to "0" (default for normal measurement) or "1" (default for integration).

- If default for normal measurement is selected, items displayed on displays C and D are the same as those output on channels 13 and 14.
  Therefore, these output types (channels 13 and 14) will be changed if types on displays C and D are changed.

OD

Requests output of measured data.

Syntax: OD <terminator>

Description:
- The OD command should be used only in addressable mode A. If the OD command is used in addressable mode B, execution error 11 will occur. Setting the addressable mode should be done using a key operation.

OE

Requests output of error codes via communications.

Syntax: OE <terminator>

Response example: ERR11 <terminator>

Error code	Description
11	Command error
12	Parameter error
13	Attempted to change settings which cannot be changed while integration was in progress.
14	Attempted to set auto range mode while external shunt range was selected.
15	Attempted to execute a command that was protected.
16	Attempted to execute a command that was protected while harmonic analysis was being performed.
17	Stop time had passed when CONT key was pressed in auto print mode.
18	Data/time cannot be set properly.
20	PLL synchronization is not being performed during harmonic analysis. (unL)
21	"FrqLo" occurs during harmonic analysis.
30	File data failure
41	Attempted to start integration when integration had been stopped due to an irregularity.
42	Attempt made to start integration during integration.
43	Measurement stopped due to overflow during integration or due to a power failure.
44	Attempt made to stop integration while integration was interrupted.
45	Attempt made to reset integration while integration was in progress.
46	Attempt made to start integration when peak overflow was detected.
47	Attempt made to start integration when integration timer preset time was set to "0".
48	Attempt made to start integration, after the stop time had already passed.
50	No conversion complete signal has been returned from A/D converter.
51	Measurement data overflow occurred. "-oL" is displayed.
52	Voltage peak overflow occurred
53	Current peak overflow occurred
54	Power factor exceeded "2". "PFErr" is displayed.
55	"degErr" was displayed.
56	Frequency input level was too low or below measurement range. "ErrLo" is displayed.
57	Frequency was above the measurement range. "ErrHi," is displayed.
58	Computation overflow occurred. "—oF—" is displayed.

OF/OF?

Sets communication output information types/inquires about the current settings.
Up to 14 measured data can be selected and output.

Syntax: OF m1,m2,m3 <terminator>

"m1" indicates communication output channel, and must be set within the following range.

$1 \leqq m1 \leqq 14$

"m2" indicates output type no.

m2=0 : No output
1 : Voltage (V)
2 : Current (A)
3 : Power (W)
4 : Reactive power (var)
5 : Apparent power (VA)
6 : Power factor (PF)
7 : Input voltage frequency (V Hz)
8 : Input current frequency (A Hz)
9 : Watt-hour (Wh)
10 : Ampere-hour (Ah)
11 : Phase angle (deg)
12 : Voltage peak (V peak)
13 : Current peak (A peak)
14 : Efficiency
15 : Integration time

"m3" indicates element, and must be set within the following range.

$1 \leqq m3 \leqq 4$

Inquiry: OF1? <terminator>

Response example: OF1,3,2

Description:
- Parameter error 12 will occur if "m1", "m2" or "m3" is set to an illegal value.
- It is possible to select "no output", efficiency or integration time whichever element is selected. However, it is best to set the element to "1".

OFD/OFD?

Initializes communication output information type/inquires about the current settings. Two sets of default setting are available: one is for normal measurement and the other is for integration.

Syntax: OFD m <terminator>

"m" indicates default no.

m=2 : Select mode (valid only for the inquiry command)

0 : Default for normal measurement
1 : Default for integration

Inquiry: OFD? <terminator>
Response example: OFD1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Select mode (OFD2) is validated when the OF command is executed if "m" is set to "0" (default for normal measurement) or "1" (default for integration).
- If default for normal measurement is selected, the information displayed on displays C and D is the same as that output on channels 13 and 14.
  Therefore, this output information (channels 13 and 14) will be changed if the information on displays C and D is changed.

OS

Requests output of panel set-up information via communications.

Syntax: OS <terminator>
Response example:

Line 1 : Model name
MODEL253130 <terminator>
Line 2 : Voltage range
RV1,9;AV1,0;RV2,9;AV2,0;RV3,9;AV3,0 <terminator>
Line 3 : Current range
When CM0 is set:
RA1,10;AA1,0;RA2,10;AA2,0;RA3,10;AA3,0;SA1.0000 <terminator>
When CM1 is set:
RA1,10;AA1,0;SA1,1.0000;RA2,10;AA2,0;SA2,1.0000;RA3,10;AA3,0;SA3,1.0000 <terminator>
Line 4 : Display function
DA1;DB2;DC3;DD3; <terminator>
Line 5 : Element
EA1;EB1;EC1;ED1 <terminator>
Line 6 : Measurement condition
WR1;FL0;CF3;SC0;AG0;HD0;SI2;MT0 <terminator>
Line 7 : Measurement mode
MV1,0;MV2,0;MV3,0;MA1,0;MA2,0;MA3,0 <terminator>
Line 8 : Scaling constant
When CM0 is set:
KV1.0000;KA1.0000;KW1.0000 <terminator>
When CM1 is set:
KV1,1.0000;KA1,1.0000;KW1,1.0000;
KV2,1.0000;KA2,1.0000;KW2,1.0000;
KV3,1.0000;KA3,1.0000;KW3,1.0000 <terminator>
Line 9 : Averaging setting
AT0;AC1 <terminator>
Line 10 : Integration setting
IC0;TM0,0 <terminator>
Line 11 : Command group used
CM1 <terminator>
Line 12 : Output end
END <terminator>

Description:
- The number of lines varies depending on the options used.
  When the printer is used, the following line must be inserted before the end line.
  PR0;PI0,0,10 <terminator>
- When the harmonic analysis option is used, the following line must be inserted before the end line.
  DH1;PS1;HA0 <terminator>
- When the D/A output option is used, the following line must be inserted before the end line.
  RT0,1 <terminator>
- When a CM0 is issued, if the shunt current values or scaling values set for each element differ from each other, the value set for element 1 will be output.

PI/PI?

Sets print interval in auto print mode/inquires about the current setting.

Syntax: PI m1,m2,m3 <terminator>
"m1" indicates hour, and must be set within the following range.
0 ≤ m1 ≤ 99
"m2" indicates minute, and must be set within the following range.
0 ≤ m2 ≤ 59
"m3" indicates second, and must be set within the following range.
10 ≤ m3 ≤ 59

Inquiry: PI? <terminator>
Response example: PI10,0,0
Description:
- Parameter error 12 will occur if any illegal value is set.

PO

Prints out measured data.

Syntax: PO <terminator>
Description:
- This command is valid whether print mode is auto or manual.

PP

Prints out panel set-up information.

Syntax: PP <terminator>

PR/PR?

Sets print mode/inquires about the current setting.

Syntax: PR m <terminator>
"m" indicates print mode.
m=0 : Manual
1 : Auto

Inquiry: PR? <terminator>
Response example: PR1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

PT/PT?

Sets the integration start time and stop time/inquires about the current settings.

Syntax: PT m1/m2/m3/m4/m5/m6,m7/m8/m9/m10/m11/m12 <terminator>
"m1" indicates start year, and must be set within the following range.
1993 ≤ m1 ≤ 2092
"m2" indicates start month, and must be set within the following range.
1 ≤ m2 ≤ 12
"m3" indicates start day, and must be set within the following range.
1 ≤ m3 ≤ 30, 31, 28 or 29
"m4" indicates start hour, and must be set within the following range.
0 ≤ m4 ≤ 23
"m5" indicates start minute, and must be set within the following range.
0 ≤ m5 ≤ 59
"m6" indicates start second, and must be set within the following range.
0 ≤ m6 ≤ 59

"m7" indicates stop year, and must be set within the following range.
1993 ≦ m7 ≦ 2092
"m8" indicates stop month, and must be set within the following range.
1 ≦ m8 ≦ 12
"m9" indicates stop day, and must be set within the following range.
1 ≦ m9 ≦ 30, 31, 28 or 29
"m10" indicates stop hour, and must be set within the following range.
0 ≦ m10 ≦ 23
"m11" indicates stop minute, and must be set within the following range.
0 ≦ m11 ≦ 59
"m12" indicates stop second, and must be set within the following range.
0 ≦ m12 ≦ 59

Inquiry: PT? <terminator>
Response example: PT2002/1/1/0/0/0,2001/1/3/0/0/0
Description:
- Parameter error 12 will occur if any illegal value is set.
- If the stop time is before the start time, parameter error 12 will occur.

RA/RA?

Sets current range/inquires about the current setting.

Syntax: RA m1,m2 <terminator>
"m1" indicates input element.
m1=0 : All elements
1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"m2" indicates current range.
m2=5 : 1 A range
6 : 2 A range
7 : 5 A range
8 : 10 A range
9 : 20 A range
10 : 30 A range
15 : 50 mV range
16 : 100 mV range
17 : 200 mV range

Inquiry: RAm1? <terminator>
Response example: RA1,9
Description:
- Parameter error 12 will occur if "m1" or "m2" is set to an illegal value.
- Changing of the current range is not allowed while integration is in progress: execution error 13 will occur.
- The 50 mV, 100 mV and 200 mV ranges are for the external shunt. When using any of these ranges, be sure to set a valid shunt value using the SA command.
- The value entered by RAm1? indicates the input element selected. If "0" is set, error 12 will occur.

RC

Initializes panel set-up information.

Syntax: RC <terminator>

RT/RT?

Sets the rated integration time when integrated values are to be output as an analog signal/inquires about the current setting.

Syntax: RT m1,m2 <terminator>
"m1" indicates hour, and must be set within the following range.
0 ≦ m1 ≦ 999
"m2" indicates minute, and must be set within the following range.
0 ≦ m2 ≦ 59

Inquiry: RT? <terminator>
Response example: RT10,0
Description:
- Parameter error 12 will occur if either "m1" or "m2" is set to an illegal value.

RV/RV?

Sets voltage range/inquires about the current setting.

Syntax: RV m1,m2 <terminator>
"m1" indicates input element.
m1=0 : All elements
1 : Element 1
2 : Element 2 (possible only for the 253130)
3 : Element 3
"m2" indicates voltage range.
m2=2 : 10V range
3 : 15 V range
4 : 30 V range
5 : 60 V range
6 : 100 V range
7 : 150 V range
8 : 300 V range
9 : 600 V range

Inquiry: RVm1? <terminator>
Response example: RV1,9
Description:
- Parameter error 12 will occur if either "m1" or "m2" is set to an illegal value.
- Changing of the voltage range is not allowed while integration is in progress: execution error 13 will occur.
- The value entered by RVm1? indicates the input element selected. If "0" is set, error 12 will occur.

SA/SA?

Sets the external shunt current/inquires about the current setting.

Syntax: When CM0 is set:
SA n <terminator>
When CM1 is set:
SA m,n <terminator>
"m" indicates element.
m=0 : All elements (Setting not allowed during inquiry)
1 : Element 1
2: Element 2 (possible only for the 253130)
3 : Element 3
"n" indicates shunt current value.
0.0200 ≦ n ≦ 100.00

Inquiry: When CM0 is set:
SA? <terminator>
When CM1 is set:
SAm? <terminator>

Response example: When CM0 is set:
SA1.0000
When CM1 is set:
SA1,1.0000
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Error 12 will occur when an inquiry is made if the shunt current values set for each element by CM0 differ from each other.

SC/SC?

Determines whether or not to use the scaling function/inquires about the current setting.

Syntax: SC m <terminator>
"m" indicates whether scaling is ON or OFF.
m=0 : OFF
1 : ON
Inquiry: SC? <terminator>
Response example: SC1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

SI/SI?

Sets the sample rate/inquires about the current setting.

Syntax: SI m <terminator>
"m" indicates sample rate.
m=0 : 250 ms
1 : 500 ms
2 : 2.0 s
Inquiry: SI? <terminator>
Response example: SI1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

SL

Recalls panel set-up information from a selected file.

Syntax: SL m <terminator>
"m" indicates file no., and must be set within the following range.
1 ≤ m ≤ 8
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- It is not possible to recall communications-related information (communication mode, address etc.) using this command.

SS

Stores panel set-up information into a selected file.

Syntax: SS m <terminator>
"m" indicates file no., and must be set within the following range.
1 ≤ m ≤ 8
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- The following set-up information can be stored:
All set-up information which can be output by the OS command
Information related to communications (GP-IB, RS-232-C etc.)

TI/TI?

Sets the time on the 2531's internal clock/inquires about the current setting.

Syntax: TI m1,m2,m3 <terminator>
"m1" indicates hour, and must be set within the following range.
0 ≤ m1 ≤ 23
"m2" indicates minute, and must be set within the following range.
0 ≤ m2 ≤ 59
"m3" indicates second, and must be set within the following range.
0 ≤ m3 ≤ 59
Inquiry: TI? <terminator>
Response example: TI17/15/0
Description:
- Parameter error 12 will occur if either "m1", "m2" or "m3" is set to an illegal value.

TM/TM?

Sets integration timer preset time/inquires about the current setting.

Syntax: TM m1,m2 <terminator>
"m1" indicates hour, and must be set within the following range.
0 ≤ m1 ≤ 999
"m2" indicates minute, and must be set within the following range.
0 ≤ m2 ≤ 59
Inquiry: TM? <terminator>
Response example: TM0,10
Description:
- Parameter error 12 will occur if either "m1" or "m2" is set to an illegal value.

WR/WR?

Sets the wiring system/inquires about the current setting.

Syntax: WR m <terminator>
m=1 : 1ø2W
2 : 1ø3W
3 : 3ø3W
4 : 3ø4W (available only for the 253130)
5 : 3V3A (available only for the 253130)
Inquiry: WR? <terminator>
Response example: WR1
Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

```
100 '*****************************
110 '* READ OUTPUT DATA (NORMAL) * GP-IB
120 '*****************************
130 ' ------------------------------------
140 '                ** Basic Declarations **
150 CLEAR ,50000!
160       IBINIT1 = 50000!
170       IBINIT2 = IBINIT1 + 3
180       BLOAD "bib.m",IBINIT1
190       CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,IBR
SC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
200       CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,I
BRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,IBSTA%,IBERR%,IBCNT%)
210 ' ------------------------------------
220 DEVICE$="M2531"
230 CALL IBFIND(DEVICE$,M2531%)
240 IF M2531%<0 THEN 570
250 V% = &HA+&H400
260 CALL IBEOS(M2531%,V%)
270 V%=1
280 CALL IBEOT(M2531%,V%)
290 '
300 CMD$ = "WR4;CF3;HD0;SI1;FL0;SC0;AG0"
310 CALL IBWRT(M2531%,CMD$) : GOSUB 600
320 CMD$ = "DA3;EA1;DB3;EB2;DC3;EC3;DD3;ED4"
330 CALL IBWRT(M2531%,CMD$) : GOSUB 600
340 CMD$ = "RV1.6;RV2.6;RV3.6"
350 CALL IBWRT(M2531%,CMD$) : GOSUB 600
360 CMD$ = "RA1.6;RA2.6;RA3.6"
370 CALL IBWRT(M2531%,CMD$) : GOSUB 600
380 CMD$ = "MV1.0;MV2.0;MV3.0"
390 CALL IBWRT(M2531%,CMD$) : GOSUB 600
400 CMD$ = "MA1.0;MA2.0;MA3.0"
410 CALL IBWRT(M2531%,CMD$) : GOSUB 600
420 CMD$ = "OFD0;DL0"
430 CALL IBWRT(M2531%,CMD$) : GOSUB 600
440 '
450 FOR I = 1 TO 10
460     BUF$ = SPACE$(255)
470     CMD$ = "OD"
480     CALL IBWRT(M2531%,CMD$) : GOSUB 600
490     CALL IBRD(M2531%,BUF$)  : GOSUB 600
500     PRINT LEFT$(BUF$,IBCNT%-2)
510     IF LEFT$(BUF$,3)<>"END" THEN 490
520 NEXT I
530 '
540 CALL IBLOC(M2531%)
550 END
560 '
570 ' *** When IBFIND call failed ***
580 PRINT " ----- No such board or device name ----- "
590 GOTO 540
600 ' *** GP-IB error check ***
610 IF IBSTA% >= 0 THEN RETURN
620 PRINT " ----- Error ----- "
630 GOTO 540
```

For Users Using Communication Commands of Digital Power Meter 2533E

The 2531 differs from the 2533E in communications command and data format. The 2531 has a function which enables the user to use communications programs created for the 2533E. This function is describedbelow in detail.

Communications Commands

To use 2533E command group with the 2531, setting command "**CM**" is required. Description is given below for the "**CM**" command and those commands which differ from the 2531 when the 2533E command group is selected.

Note

- For addressable mode setting method, refer to Section "11.1 Using the GP-IB Interface" (page 11-8).
- 2531 code format is used for error code and status byte. For details, refer to Sections "13.2 Error Codes and Corrective Actions" (page 13-2) and "11.1 Using the GP-IB Interface" (page 11-3). 2531 code format differs from 2533E code format.
- To read harmonics analysis data via the RS-232-C, select a value other than "0" for handshake mode since harmonics analysis data consists of a number of output bytes.

AA/AA? — Sets auto or manual range mode for the current ranges/inquires about the current setting.

Syntax: AA m <terminator>
"m" indicates whether range mode is auto or manual.
m=0 : Manual range
1 : Auto range

Inquiry: AA? <terminator>

Response example: AA0

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- All elements are switched ON or OFF.
- Error 12 will occur when an inquiry is made if the range modes set for each element differ from each other.

AV/AV? — Sets auto or manual range mode for the voltage ranges/inquires about the current setting.

Syntax: AV m <terminator>
"m" indicates whether range mode is auto or manual.
m=0 : Manual range
1 : Auto range

Inquiry: AV? <terminator>

Response example: AV0

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Auto range for all elements is turned ON or OFF at once.
- Error 12 will occur when an inquiry is made if the range modes set for each element differ from each other.

DS — Sets the delimiter E01 output timing. This command is used with the 2533E, but cannot be used with the 2531 even if 2533E command group is selected by the "CM" command.

KV/KV?, KA/KA?, KW/KW? — Sets the scaling constant/inquires about the current setting. KV is used for voltage measurement, KA for current measurement, and KW for power measurement.

Syntax: KV m <terminator>
KA m <terminator>
KW m <terminator>
"m" indicates scaling constant, and must be set within the following range.
$0.001 \leqq m \leqq 10000.$

Inquiry: KV? <terminator>
KA? <terminator>
KW? <terminator>

Response example: KV1.0000
KA1.0000
KW1.0000

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Voltage, current and power scaling constant for all elements are set to the same value.

MN/MN? — Sets the measurement mode/inquires about the current setting.

Syntax: MN m <terminator>
"m" indicates measurement mode.
m=0 : RMS
1 : MEAN
2 : DC

Inquiry: MN? <terminator>

Response example: MN0

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- The same measurement mode is selected for both voltage and current for all elements.
- Error 12 will occur when an inquiry is made if the measurement modes set for each element differ from each other.

OL

Requests output of setup information. Output format differs from that of the 2533E.

Syntax: OL <terminator>

Response example:

MODEL253130 <terminator>
RV9:AV0 <terminator>
RA9:AA1:SA1.000 <terminator>
DA1:DB2:DC3:DD3 <terminator>
EA1:EB1:EC1:ED1 <terminator>
WR1:CF3:SI1:FL0:SC0:AG0:MT0 <terminator>
MN0 <terminator>
KV1.0000:KA1.0000:KW1.0000 <terminator>
AT0:AC1 <terminator>
IC0:TM0,0 <terminator>
CM2 <terminator>
RT0,0 <terminator>
PR0:PI1,0,0 <terminator>
DH0:PS1:HA0:AF0 <terminator>
END <terminator>

Description:
- When the range, auto range's ON/OFF state, measurement modes, shunt current values, scaling values set for each element differ from each other, the value set for element 1 will be output.

OS

Requests output of setup information. This command cannot be used if 2533E command group is selected by the "CM" command. However, in this case "OL" command can be used instead.

RA/RA?

Sets current range/inquires about the current setting.

Syntax: RA m <terminator>

"m" indicates current range.

m=5 : 1 A range
6 : 2 A range
7 : 5 A range
8 : 10 A range
9 : 20 A range
10: 30 A range
15: 50 mV range
16: 100 mV range
17: 200 mV range

Inquiry: RA? <terminator>

Response example: RA9

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- The same current range is selected for all elements.
- Error 12 will occur when an inquiry is made if the current range set for each element differ from each other.

RV/RV?

Sets voltage range/inquires about the current setting.

Syntax: RV m <terminator>

"m" indicates voltage range.

m=2 : 10 V range
3 : 15 V range
4 : 30 V range
5 : 60 V range
6 : 100 V range
7 : 150 V range
8 : 300 V range
9 : 600 V range

Inquiry: RV? <terminator>

Response example: RV9

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- The same voltage range is selected for all elements.
- Error 12 will occur when an inquiry is made if the voltage range set for each element differ from each other.

SA/SA?

Sets the external shunt current/inquires about the current setting.

Syntax: SA m <terminator>

"m" indicates shunt current, and must be set within the following range.

$0.02 \leqq m \leqq 100.0$

Inquiry: SA? <terminator>

Response example: SA1.0000

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.
- Shunt current value for all elements is set to the same value.

WR/WR?

Sets the wiring system/inquires about the current setting.

Syntax: WR m <terminator>

"m" indicates wiring system.

m=0 : 3ø3W
1 : 3ø4W (available only for the 253130)
2 : 1ø2W
3 : 1ø3W
4 : 3V3A (available only for the 253130)

Inquiry: WR? <terminator>

Response example: WR0

Description:
- Parameter error 12 will occur if "m" is set to an illegal value.

Data format

To read measured data using 2533E communication program, 2531 addressable mode B must be set. Output items do not match those displayed on each display as in the 2533E, but match those set for ch.1 to ch.3 in output function setting for the 2531. Select output items according to the 2533E communications program.

Note

- 2531 output items for ch.4 and subsequent ch.nos. are not output.
- For detailed description for output function setting, refer to Section 9.2 "Setting Printer Output Functions" (page 9-2 to 9-4).

Data Output Format

Data consists of a 12-byte header and 12 bytes of data.
The entire data output format is shown below.

ch.1header	ch.1data	,	ch.2header	ch.2data	,	ch.3header	ch.3data

Header Section

h1	h2	h3	h4	h5	h6	h7	h8	h9	h10	h11	h12

h1 to h2 : Output channel
DA : ch.1
DB : ch.2
DC : ch.3

h3 to h4 : Data type

1 : V (Voltage)	6 : PF (Power factor)	11 : DEG (Phase angle)
2 : A (Current)	7 : HzV (Voltage frequency)	12 : Vpk (Peak voltage)
3 : W (Power)	8 : HzA (Current frequency)	13 : Apk (Peak current)
4 : var (Reactive power)	9 : Wh (Watt-hour)	14 : EFF (Efficiency)
5 : VA (Apparent power)	10 : Ah (Ampere-hour)	15 : IT (Integration time)

Note

- If "15" is set to h4 and h5 when "DB" is set to h1 and h2, "DB4_" is output to h1 through h4. This is done to conform to 2533E format.

h5 to h6 : Output channel
EA : ch.1
EB : ch.2
EC : ch.3

h7 : Element
1 : Element 1
2 : Element 2
3 : Element 3
4 : Σ

h8: Data state
N : Normal
I : Overrange/no data
O : Computation overflow

h9 to h11 : Unit

V__ : V	VA_ : VA	Ah_ : Ah
A__ : A	HZ_ : Hz	AUX : Arbitrary
W__ : W	Wh_ : Wh	__ : Other
VAR : var		

h12 : Fixed to ".".

Data Section

d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11	d12

d1 : Polarity : _ (space) or — (minus)
d2 to d9 : Mantissa, floating-point number of the maximum seven digits
d10 to d12 : Exponent (power)
E-3 → m
E+0
E+3 → k
E+6 → M

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